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MONTHLY WEATHER REVIEW

Editor, W. J. HUMPHREYS

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SOME ADDITIONAL FACTS ABOUT THE CLIMATE OF DEATH VALLEY, CALIF.

By ERNEST E. EKLUND

[Weather Bureau, San Francisco, Calif., June 5, 1931]

Since the days of the pioneers when emigrants braved the heat and the parched and trackless wastes of Death Valley in their efforts to reach the Pacific coast, this spot has held romantic and historical interest and has furnished the background for many tales based upon the hardships of these pioneers and upon the many tragic scenes that have been enacted there.

Death Valley, one of the typical desert regions in the United States, is located in southeastern California near the Nevada boundary. It extends between high mountain ranges in a generally north-south direction a distance of some 100 miles and averages about 10 miles in width. More than 400 square miles are below sea level. The deepest depression in the United States, 276 feet below sea level, is found in Death Valley, although Mount Whitney, the highest point in the United States, 14,496 feet, is only 86 miles to the west-northwest.

A first-order station of the Weather Bureau was established in Death Valley on April 30, 1891, and continuous observations were made during the next 5 months. No further records were made there until June 1911, when a climatological station of the Weather Bureau was established through the cooperation of the Pacific Coast Borax Co. The station was established at Greenland Ranch, probably better known as Furnace Creek Ranch, a tract of about 70 acres under irrigation, situated on the eastern side of the valley, in latitude 36°27′ N. and longitude 116°50′ W., not far from the location of the former station. The elevation of the station is 178 feet below sea level, 98 feet higher than the lowest part of the valley. Observations have been continued since June 1911, so records for 20 years are available. Harrington (1) and others have discussed the climate of Death Valley, the later discussions being based on the records made at Greenland Ranch. The purpose of the present paper is to review these records and point out such salient facts as may be gleaned from the longer record now available.

Discussions of the climate of Death Valley have stressed the high temperatures recorded there, and without doubt temperature is the outstanding climatic feature. Maximum temperatures ranging from 125° F. to 130° F. have been recorded at a number of stations in the desert regions of southeastern California, but on July 10, 1913, an extreme maximum temperature of 134° F. was recorded at Greenland Ranch. This is the highest natural-air shade temperature ever recorded officially in California. The record has been investigated and has been accepted as reliable, and in this connection Mr. F. W. Corkill, mill superintendent of the Pacific Coast Borax Co., stated, "Regarding the temperature of 134° F., which was recorded (at Greenland Ranch) on July 10, 1913, I will state that this record should be considered correct." (2) He goes on to state that a man perished that day and his chauffeur almost lost his life; a high wind prevailed but he did not recall whether it was from the north or south. This temperature of 134° F. was recognized as the highest authentic natural-air temperature that, to that time, had ever been recorded anywhere under approved conditions of equipment and exposure. Higher temperatures had been reported but were never accepted as trustworthy. Greenland Ranch thus had the distinction of holding the world's record for extreme high temperature, and this record stood until September 13, 1922, when a temperature of 136° F. was recorded at Azizia, Tripoli. This, according to the Meteorological Glossary of the British Meteorological Office, is the world's absolute extreme high temperature.

High temperatures are by no means rare in Death Valley, judging from the records of Greenland Ranch, and it seems probable that even higher temperatures occur on the floor of the Valley, 98 feet lower than Greenland Ranch, considering the probable cooling effect of irrigated land and green vegetation at Greenland Ranch and the greater effect of insolation at the lower elevation. Extreme maximum temperatures of 120° F. or higher have occurred at Greenland Ranch in every month from May to September, inclusive, and such temperatures have occurred there each year since the record began. In July 1929 the mean maximum temperature was 119.5° F.

Temperatures of 100° F. or higher have occurred each month from March to October, inclusive, and temperatures of 85° F. or higher have occurred during every month of the year. The average number of days with maximum temperature of 120° F. or higher in June is 4, in July, 10, and in August, 5. In July and August 1917 maximum temperatures of 120° F. or higher were recorded on 43 consecutive days and during the same summer maximum temperatures of 100° F. or higher were recorded on 113 consecutive days. This record was exceeded in 1916, however, when 126 consecutive days fell within this classification. Records of this sort are comprehensible when one considers the fact that maximum temperatures of 100° F. or higher are of almost daily occurrence in June, July, and August and that a monthly mean temperature of 106.8° F. occurred in July 1922.

High temperatures at Greenland Ranch have been emphasized so often that one might be led to believe that the weather is never cool there. This is by no means true. Temperatures of 32° F. or lower have been recorded from October to March, inclusive; and in December, January, and February 1928–29 there were 72 consecutive days on which the temperature fell to the freezing point or lower. The absolute extreme low temperature at Greenland Ranch, 15° F., occurred on January 8, 1913, and the minimum temperature on the following day was 16° F. When the observer made on his record sheet the

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notation, "Unusually cold for Death Valley" he could not realize that he was writing about the absolute extreme minimum temperature in a record covering 20 years. The significance of his notation is supported by the fact that extreme low temperatures occurred at many places in California during that cold spell. In this connection, it is interesting to note that the highest temperature and the lowest temperature ever recorded at Greenland Ranch occurred in the same year and nearly 6 months apart. The lowest monthly mean minimum temperature ever recorded there was 24.5° F. in January 1929, and in January 1919 the monthly mean temperature was only 43.0° F. Thus Death Valley has a winter season when freezing weather frequently occurs.

The nights are comfortably cool as a rule from October to April, inclusive, when the minimum temperatures average less than 60° F. Minimum temperatures during midsummer are quite different. The mean minimum temperature in July is 87.6° F. Minimum temperatures of 90° F. or higher are not unusual in June, July, and August, and have been recorded occasionally in April, May, and September. Minimum temperatures of 100° F. or higher are not unknown. In August 1924 there were 12 consecutive nights (19th to 30th) when the temperature did not go lower than 100° F. The maximum temperature during this period was 124° F. In July and August 1929 there were 46 consecutive nights when the temperature did not go lower than 90° F.

In general, then, the summer months are uncomfortably hot and the winter months are comfortably cool, the hottest month being July with a mean temperature of 102.0° F. and the coolest January with a mean temperature of 51.4° F. The mean daily range in temperature varies from 27.6° F. in December to 33.2° F. in September. During the hottest months, July and August, the mean daily range in temperature is not quite so large as in the months immediately preceding and following, due no doubt to the inability of the ground to radiate during the night the store of heat that accumulates during the daytime. Daily ranges in temperature of 40° F. or more may be expected from March to November, inclusive, 38° F. in January and February, and 33° F. in December; but daily ranges of 50° F. or more have been recorded in practically all months, while on September 28, 1924, an extreme daily range of 67° F. was recorded, from 112° F. to 45° F.

In the foregoing a number of periods have been mentioned during which unusual temperatures were recorded at Greenland Ranch and it may be of interest to note the outstanding features of the temperatures during some of those periods, as follows:

HOT SPELL WITH EXTREME MAXIMUM TEMPERATURE 134° F.

Date	Maximum	Minimum	Mean	Range
1913				
July 4	119	77	98	42
July 5	126	73	100	53
July 6	125	89	107	36
July 7	127	89	108	38
July 8	128	90	109	38
July 9	129	93	111	36
July 10	134	85	110	49
July 11	129	85	107	44
July 12	130	85	108	45
July 13	131	85	108	46
July 14	127	86	106	41
July 15	119	86	102	33

43 CONSECUTIVE DAYS WITH MAXIMUM TEMPERATURE 120° F. OR HIGHER

Period	Temperature	Date
July 6 to Aug. 17, 1917	Highest, 125	July 12.
	Lowest, 76	Aug. 13 and 14.

72 CONSECUTIVE DAYS WITH MINIMUM TEMPERATURE 32° F. OR LOWER

Period	Temperature	Date
Dec. 2, 1928, to Feb. 11, 1929	Highest, 74	Dec. 7.
	Lowest, 20	Jan. 22.

COLD SPELL WITH EXTREME MINIMUM TEMPERATURE 15° F.

Date	Maximum	Minimum	Mean	Range
1913				
Jan. 7	50	20	35	30
Jan. 8	50	15	32	35
Jan. 9	58	16	37	42

Comparative temperature data, as well as other data, based on the records made at Greenland Ranch from 1911 to 1930, inclusive, are presented in table 1, and some of the data are shown in graphic form in figure 1.

Although many persons have died, no doubt, on account of the heat in Death Valley, it is probable that by far the greater number of tragic deaths have been from thirst. Drinkable water is not obtained readily and to the unfortunate travelers in Death Valley rain would have been a godsend, but the records indicate that it would sometimes be a long while between drinks if dependence were placed upon the occurrence of rain in sufficient quantity to allay thirst. Recently the statement was made by one who should have been better informed that rain never falls in Death Valley because the water evaporates before it reaches the ground. To be sure the average precipitation is light but the situation is hardly as bad as this statement indicates. Several times in the last 20 years one could have visited Death Valley for 6 months or more at a time and, based on his own observations, could have said truthfully that no rain falls there. He could have spent the whole year of 1929 there without seeing even a drop of rain and had this stay included part of December 1928, and part of January 1930 the visitor would have witnessed 401 consecutive days on which no measurable precipitation occurred. This record for consecutive days without measurable precipitation has been exceeded at other stations in the deserts of southeastern California but nevertheless the average annual rainfall at Greenland Ranch, 1.38 inches, is less than that of any other California station. Rain is liable to fall at Greenland Ranch in any month of the year and there is no well-defined rainy season such as characterizes the climate of the Pacific coast in general. Rainfall of 0.01 inch or more in 24 hours occurs on the average only seven times a year and the frequency of rainfall is not much greater if immeasurable amounts, or traces, are also included. In January, February, and March, measurable rainfall occurs on the average 1 day each month while in practically all other months the average number of rainy days is considerably less than one half. The greatest number of rainy days in 1 year was in 1913 when measurable rainfall occurred on 16 days and the least in 1929 when no rain, not even a trace, was recorded. The greatest number of rainy days in any 1 month was 5 in March 1918, but the total monthly precipitation was only 0.75 inch. A daily rainfall of 1 inch or more has been recorded at Greenland Ranch only four times in nearly 20 years and the greatest amount ever recorded in 24 hours is 1.40 inches. This amount fell between 3 p.m. September 29 and 1 p.m. September 30, 1911, and the observer made the notation "Heaviest rain for several years." On November 9, 1923, however, precipitation of 1.40 inches was recorded when the observation was taken at 5 p.m. and the next

day the precipitation was recorded as 0.30 inch but the hours of beginning and ending are not given so it is possible that the total of 1.70 inches occurred within 24 hours. At any rate, this is the heaviest rain that ever occurred at Greenland Ranch on 2 consecutive days and it is also the greatest monthly precipitation of record with one exception. The heaviest monthly rainfall, 1.90 inches, occurred in February 1913. The wettest year was 1913 when 4.54 inches of rain fell and the driest was 1929 which was rainless. Comparative precipitation data are included in table 1.

Although rainfall is scanty in Death Valley, heavy precipitation occurs in the mountains on each side. These rains are frequently very local and, especially in summer, occur as the result of thunderstorms, but they produce torrents in the canyons that discharge into Death Valley. These torrents cause the combed appearance of

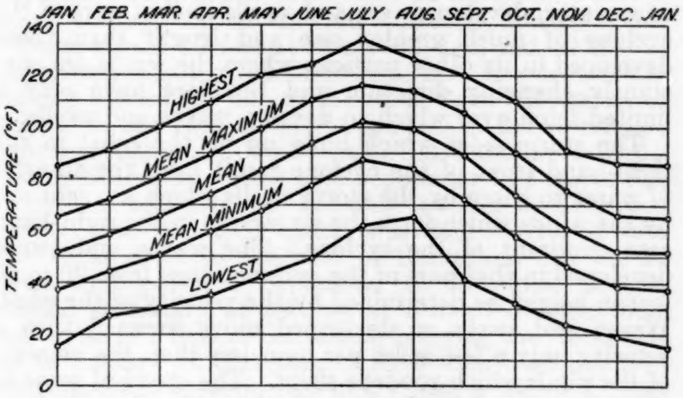

FIGURE 1.—Temperature graph of Greenland Ranch, Calif., for the period 1911–30, inclusive.

the surfaces over which they flow, and sometimes do considerable damage to roads. While thunderstorms are no doubt frequent in the mountains which rise on each side of Death Valley, they occur much less frequently within the valley. Clouds occur frequently, however, and cloudy days are by no means uncommon, although by far the larger number of days are recorded clear. Few partly cloudy days appear in the record, but the average number of clear days and the average number of cloudy days each month are included in the comparative data in table 1.

No systematic records of relative humidity have been made in Death Valley over any considerable period, but McAdie (3) states that hygrographic records covering one year indicate that while the relative humidity is low there are periods when a high percentage of saturation prevails and that apparently the relative humidity in Death Valley is not much lower than that of the Great Valley of California. Palmer (4) states that occasional determinations of relative humidity indicate values as low as 5 percent in summer. Lower relative humidities have been determined in connection with the fire-weather observations in California and it therefore appears logical to assume that in Death Valley the relative humidity is sometimes considerably less than 5 percent on summer days. No doubt considerable variations in relative humidity would be found within the valley, depending upon the place of observation in relation to wind direction and source of moisture. Contrary perhaps to general belief, numerous sources of water such as springs, rivers and marshes, usually highly mineralized, exist in or adjacent to Death Valley (5).

Records of wind direction in Death Valley are not complete but they indicate that the prevailing winds are from the south and southeast, with northerly winds having the next greatest frequency. This is to be expected, considering that high mountain ranges lie to the east and west, but topographical influences such as canyons and ridges no doubt produce local deviations from the general north-south circulation of the valley. Available records indicate that the air in Death Valley is not stagnant but that it is in active motion usually and that high winds, sometimes accompanied by sandstorms, are not infrequent.

TABLE 1.—*Comparative data, Greenland Ranch, Calif. (1911–30)*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Mean temperature	51.4	58.1	65.5	74.6	83.4	94.0	102.0	98.9	88.9	74.0	60.6	52.0	75.3
Mean maximum temperature	64.9	72.3	80.4	89.6	99.1	110.4	116.4	113.7	105.5	90.3	75.6	65.8	90.3
Mean minimum temperature	36.9	43.9	50.6	59.5	67.7	77.6	87.6	84.0	72.3	57.7	46.3	38.2	60.2
Mean daily range	28.0	28.4	29.8	30.1	31.4	32.8	28.8	29.7	33.2	32.6	29.3	27.6	30.1
Greatest daily range	50	53	49	52	52	53	56	50	67	57	51	46	67
Highest temperature	85	91	100	109	120	124	134	126	120	110	91	86	134
Lowest temperature	15	27	30	35	42	49	62	65	41	32	24	19	15
Maximum 120° F. or higher	0	0	0	0	1	10	29	17	0	0	0	0	52
Maximum 100° F. or higher	0	0	0	8	29	30	31	31	30	16	0	0	159
Minimum not less than 100° F	0	0	0	0	1	10	12	16	3	0	0	0	17
Minimum not less than 90° F	0	0	0	4	4	15	31	28	9	0	0	0	81
Minimum 32° F. or lower	31	12	1	0	0	0	0	0	0	3	6	30	57
Average precipitation	0.31	0.27	0.15	0.04	0.05	0.03	0.06	0.04	0.09	0.08	0.18	0.08	1.38
Greatest total precipitation	1.51	1.90	1.10	0.28	0.40	0.60	0.60	0.40	1.40	0.35	1.70	0.60	4.54
Greatest amount in 24 hours	1.00	1.00	0.70	0.28	0.40	0.60	0.31	0.30	1.40	0.50	1.40	0.35	1.40
Greatest number of rainy days	4	4	5	2	1	1	3	3	2	1	4	2	16
Average number of clear days	23	20	25	24	24	26	25	27	27	26	24	23	294
Average number of cloudy days	8	8	6	6	7	4	6	4	3	5	6	8	71

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TIDES AND COASTAL CURRENTS DEVELOPED BY TROPICAL CYCLONES

By ISAAC MONROE CLINE

[Weather Bureau Office, New Orleans, La., December 1931]

Personal experience in dealing with high tides and hurricane winds in the tropical cyclone at Galveston, Tex., September 8, 1900, convinced me that the tides developed by these cyclones on the coast are not only their greatest destructive agency but also one of the outstanding indicators of the intensity and extent of the storm and the place toward which it is moving. During the last 30 years my position as forecaster in charge of the New Orleans forecast center has enabled me to make an extensive study of the destructive tides that accompany tropical cyclones.

History tells us that these tides have caused enormous loss of life, such as that at Calcutta, October 5, 1864, when a storm tide of 16 feet spread over the delta of the Ganges and drowned 45,000 persons; and the Backergunge cyclone, October 31, 1876, which was attended by a tide which brought the water 10 to near 50 feet over the eastern part of the delta of the Ganges and drowned more than 100,000 persons. Great loss of life from such tides has occurred also in more recent years. Notwithstanding the fact that the great loss of life was confined to the areas flooded by the storm tides, no special study of them was attempted until recently. Meteorological students generally, it appears, had assumed that the winds in the tropical cyclone had a somewhat uniform spiral inward movement around the center of the storm area which sent the waves and swells with considerable regularity in all directions. In 1849, Colonel Reid published a diagram in which he showed the swells going out from the center of the cyclone in all directions without any differentiation as to the length and size of the swell developed by the winds in different parts of the cyclone, and as late as 1900 this diagram was reproduced as representing the movement of waves and swells developed by cyclones.

Studies of these storms and the tides which they produced soon convinced me that the great loss of life caused by tropical cyclones was not from winds directly but from drowning by the tides developed by the winds, and furthermore that the storm tide does not occur except in the right-hand front of the cyclone. I asked the Chief of the Weather Bureau in October 1919 for authority to collect the automatic tide records and meteorological and other data which had been recorded in tropical cyclones from 1900 to date and make a study under the heading, "Relation in changes in storm tides on the coast of the Gulf of Mexico to the center and movement of hurricanes." Professor Marvin, Chief of the Weather Bureau, authorized me to proceed with the study and added "I do not want you to stop when you show the relation of the tide on the coast to the center and the movement of the hurricane; I want you also to show the physical forces in the cyclone which produce these tides."

Professor Marvin's instructions made it necessary that the actual directions of the winds and the physical forces in the cyclone which produce the tides be determined. To accomplish this it was necessary to use a new form of statistical analysis in the study of the phenomena of the cyclone. The integration method, which had been used by engineers in extending their flood statistics far beyond the available experience, was used in making this study. This method enabled me to get a much more complete and precise picture of the cyclone action and the distribution of the phenomena around the center of the cyclone than was possible with the use of simultaneous observations from widely scattered stations. Important characteristics of the cyclone noted in connection with this study, not brought out by previous methods of analysis of the data, are: That the winds in the right-hand rear quadrant of the cyclone have a direction which is mainly the same as that in which the cyclone is traveling, and that they continue so during the life of the cyclone. These winds form an air stream which persists in the right-hand rear quadrant of the cyclone with wind velocities of 40 to 100 miles per hour, covering a distance of some 200 miles, and in some instances tail end winds of 20 to 30 miles per hour extend farther in the rear giving this air stream a length of something like 300 miles. These winds, with a fetch of 200 to 300 miles over water, develop waves and swells in that part of the cyclone of much greater size and length than those developed in its other portions where the winds are constantly changing direction and therefore have only a limited fetch over which to develop waves and swells.

The storm tides which build up on the coast in the right-hand front of the cyclone result from the transfer of water to shore by the storm swells which are sent out by the winds which form the air stream in the right-hand rear quadrant of the cyclone. The waves and swells developed in that part of the cyclone range from 20 to 50 feet in height, as determined by the velocity of the wind. Waves and swells so developed move forward with a velocity only a few miles per hour less than the velocity of the winds which produce them. The speed of some of these waves and swells is more than 40 miles per hour while that of the cyclone may be only 12 to 15. At such speeds the waves and swells soon move through the right-hand half of the cyclone and after passing out of the cyclonic area travel on with little change of speed and reach the coast far in advance of the arrival of the storm.

In the tropical cyclone of September 26–30, 1915, we had a fine example for showing the building up of the storm tide on the Gulf coast. At Galveston, Tex., and Burrwood, La., there was a storm tide of 0.8 foot at 8 p.m. September 26. The center of the cyclone was then south of western Cuba, approaching the Yucatan Channel, but 800 miles distant from the coast on which the tide had made its appearance 3 days before the arrival of the cyclone itself. At 8 a.m. September 27 the storm tide was 1 foot from Galveston to Burrwood and had commenced rising at Fort Morgan, Ala. The storm center passed through the Yucatan Channel during the night of the 27th–28th and at 8 a.m. of the 28th there was a storm tide of 1.5 feet from Galveston to Burrwood. There was no further rise in the storm tide on the Texas coast, but at 8 p.m. of the 28th it had risen to 1.7 feet at Burrwood, La., and had extended to Fort Morgan, Ala. From 8 p.m. of the 28th to 2 a.m. of the 29th there was a rise of 1 foot in 6 hours at Burrwood, bringing the storm tide up to 2.7 feet and in the following 6 hours ending at 8 a.m. of the 29th there was an additional rise of 1 foot, bringing the storm tide at Burrwood up to 3.7 feet.

The rise in the storm tide extended well eastward on the Florida coast but there was no rise in the tide west of Isle Dernier 25 miles to the left of the path followed by the center of the cyclone. After passing through the Yucatan Channel the storm slowly curved toward the east and its center moved inland on the Louisiana coast between Burrwood and Isle Dernier. An interesting fact is that

after the storm center passed through the Yucatan Channel into the Gulf of Mexico, 8 a.m. September 28, nearly 36 hours before it reached the Louisiana coast, there was no further rise in the storm tide on the coast to the left of the point where its center moved inland but there was an additional rise of 3.5 feet at Burrwood to the right of the center, and farther to the right of the center the rise was more marked. There was no sudden and decided rise in the tide on the coast as the storm center passed inland. The greatest rise in the storm tide was about 40 miles to the right of the line followed by the storm center.

There are times when the storm tide furnishes the only concrete evidence from which conclusions can be drawn relative to changes which are taking place in the intensity of the cyclone and the direction of movement of the cyclonic center. The tropical cyclone of September 2–14, 1919, was a striking example of this nature. From 8 a.m. September 11 to 8 a.m. September 12 the cyclone moved slowly through the eastern Gulf of Mexico, and developed a storm tide of 1.7 feet at Burrwood, La., and 0.7 foot at Galveston, Tex., which indicated that the center was moving toward the mouth of Sabine Pass. However, at 8 p.m. on the 12th a shift in the rise in the storm tide appeared with a rise of 0.9 foot at Galveston and only 0.2 foot at Burrwood. At 8 a.m. September 13 a storm tide of 2.6 feet at Galveston and only 2.4 feet at Burrwood showed that the storm center was then moving toward the Texas coast to the west of Galveston. In the 12 hours ending 8 p.m. September 13 the storm tide remained stationary at 2.4 feet at Burrwood while there was a rise of 1 foot at Galveston, bringing the storm tide up to 3.6 feet at that place. At 3 a.m. September 14 Galveston had a storm tide of 7.7 feet, a rise of 4.1 feet in 7 hours. (Galveston at this time was 110 miles to the right of the line along which the cyclone center was advancing.) The storm tide rose 4 feet during the 7 hours ending at 3 a.m., September 14, which indicated that the storm center was moving toward a point on the coast to the south of Corpus Christi and that the Texas coast west of Galveston would get hurricane winds and destructive storm tides. After 3 a.m. September 14 there was no further rise in the storm tide at Galveston but it continued rising at Corpus Christi, reaching 6 feet at 8 a.m., stood at 16 feet from 4 p.m. till 6 p.m. during which time the storm center moved inland a short distance to the south of Corpus Christi, and then dropped to 6 feet at 8 p.m. These tide changes indicated the direction of movement and the intensity of the cyclone very clearly.

The barometer changes along the Texas coast were not so clear in showing the intensity and movement of the cyclone The barometer at Galveston at 8 a.m. September 13 was 29.79 inches, and at 8 p.m. 29.68 inches; on the 14th at 8 a.m. the barometer at Galveston was 29.60, the lowest recorded at that place during the passage of the cyclone. The barometer fell 0.11 inch while the storm tide rose 1 foot in the 12 hours ending 8 p.m. of the 13th, and the barometer fell only 0.08 inch while the storm tide rose 5 feet during the 12 hours ending 8 a.m. of the 14th. Here we have a total fall in the barometer of 0.19 inch at Galveston during the 24 hours preceding the passage of the storm center while the storm tide during the same time rose 6 feet. The storm tide indicated the movement and intensity of the cyclone notwithstanding its center was passing more than 100 miles distant to the left of Galveston.

At Corpus Christi, Tex., the barometer at 8 p.m. of the 13th was 29.67 inches and at 3 a.m. of the 14th 29.56 inches, showing a fall of 0.11 inch while the storm tide rose 4 feet during the same period. During the 12 hours ending 8 a.m. on the 14th the barometer fell 0.30 inch while the storm tide rose 6 feet. The center of the cyclone moved inland to the west of Corpus Christi leaving that place about 45 miles to the right of the line along which the center of the cyclone advanced. This placed Corpus Christi in the most severe part of the cyclonic area.

Another good example in which the storm tide stood out distinctly was the tropical cyclone of June 16–22, 1921, which moved inland on the Texas coast near Corpus Christi with its center passing a little to the right of that place, curving slowly toward the east. The storm tide showed up in that vicinity before the barometer at Corpus Christi commenced falling. A special observation from Corpus Christi at 4:40 p.m. June 21, showed the barometer somewhat higher than it was at 8 a.m. the same day, heavy rain falling with a maximum wind velocity of 48 miles per hour (such winds are not unusual at that place) and a storm tide of 4 feet at Corpus Christi Pass. This tide indicated that a disturbance of considerable intensity was approaching Corpus Christi at that time. No ships had encountered this disturbance during its passage from Yuctan across the Gulf of Mexico and the tide at Corpus Christi Pass was the first definite indication that a disturbance in the nature of a tropical cyclone was approaching that locality.

The development of coastal currents by the swells sent out by the winds of the right-hand rear quadrant of the cyclone is another factor of special interest in connection with erosion and enginerring projects. In the building up of the storm tide powerful currents are developed which run coastwise from right to left across the right-hand front of the cyclone. In the tropical cyclone of August 14–17, 1915, the center of which moved inland a little distance to the west of Galveston, Tex., the Trinity Shoals gas and whistling buoy, the the weight of which was 21,000 pounds, anchored with a 6,500-pound sinker and 252 feet of anchor chain weighing 3,500 pounds (total weight 31,000 pounds), was carried 8 to 10 miles coastwise to the westward of its location in latitude 29°07′ N. and longitude 92°15′ W. This buoy was anchored in 42 feet of water and was 100 miles to the right of the path followed by the center of the cyclone. Galveston Bar gas and whistling buoy with the same individual and total weights as the above, anchored at the end of the Galveston jetties in 36 feet of water was carried 4½ to 5 miles coastwise in a southwesterly direction. This buoy was located about 20 miles to the right of the path of the center of the cyclone. Another gas and whistling buoy the same size as the above, located on Heald Bank 20 miles off the entrance to Galveston Bay and to the left of the line followed by the center of the cyclone was not moved but the lights were extinguished.

Another instance of this nature was brought out in the tropical cyclone of September 6–14, 1919, which moved westward across the Gulf of Mexico and passed inland with the path of its center about 45 miles to the west of Corpus Christi. This disturbance developed coastwise currents running almost parallel to the line of advance of the storm center but they did not show the power equal to those which run across the right-hand front of the cyclone. Trinity Shoals gas and whistling buoy, already described, was 125 miles to the right of the line followed by the center of the cyclone and was moved 2½ miles to the westward. Galveston Bar buoy, already described, was 110 miles to the right of the line followed by the center of the cyclone and was carried 1½ miles to the south-

west. Aransas Pass gas and whistling buoy, weight 8,000 pounds with an anchor weighing 5,000 pounds and 252 feet of anchor chain weighting 3,528 pounds (total weight 16,528 pounds) in 42 feet of water was carried 5 miles across the right front and somewhat in toward the coast. This buoy was located in latitude 27°50′ and longitude 97°02′ about 50 miles to the right of the line followed by the center of the cyclone.

The destructive power of the storm swell is brought out in this cyclone. At Sabin Bank Light House, about 125 miles to the right of the line followed by the center of the cyclone, cast iron plates five eighths inch thick, 27 feet above the surface of the water, were bent up and crushed in by the storm swells.

Currents developed by a tropical cyclone when approaching the coast run across the right-hand front of the storm in toward the coast and contribute to the building up of the tide which is the destructive feature on the coast. In cylcones traveling coastwise, currents of considerable force are developed more than 125 miles to the right of the path of the center of the storm and run nearly parallel to the coast.

A BRIEF STUDY OF OREGON TEMPERATURES

By EDWARD LANSING WELLS

[Weather Bureau Office, Portland, Oreg., June 1931]

[Read at the meeting of the American Meteorological Society, Pasadena, Calif., June 17-19, 1931]

Four factors are prominent in the control of temperature in Oregon, namely, latitude, altitude, nearness to the ocean, and local topography. Of these factors nearness to the sea is the most important, and altitude comes next. While the State extends through more than 4° of latitude, it is probable that when everything is taken into consideration local topography will be found to be almost as important as latitude.

For this reason no discussion of Oregon temperature will be complete without reference to the geographical and topographical features of the State.

Oregon lies mostly between the forty second and forty sixth parallels, or in the latitude of northern Italy and southern France. It extends from the Pacific Ocean inland for 375 miles. The area is 96,699 square miles, including more than 1,000 square miles of water surface. This is an area greater than that of New England, New Jersey, Maryland, and Delaware, taken together.

In altitude it ranges from sea level to more than 12,000 feet. Within the city of Portland alone there is a range of more than 1,000 feet, or more than in the combined States of Illinois and Indiana.

The most prominent topographical feature is the Cascade Range of mountains, extending from north to south. with a little less than one third of the area lying to the westward. This range includes several snow-clad peaks, the highest of which, Mount Hood, rises to an elevation of 11,225 feet. The only low pass through the Cascades is the one formed by the Gorge of the Columbia River, at the northern boundary of Oregon. This gorge is cut through nearly to sea level. It is known around the world for its beauty and for its utility in providing an all-year gateway for water, rail, highway, and air transportation. It also forms a remarkable gateway for the transportation of weather, and is one of the most interesting out-door meteorological laboratories in the world.

Next in importance is the Coast Range, extending near and parallel to the coast. For most of its length this range is relatively low, but toward the south it includes some high, rugged country, and is partially connected with the Cascade Mountains by a stretch of rough, hilly country. Within this hilly region there are numerous sheltered valleys, but no wide expanses of open country. Toward the north the Cascades and Coast Range are separated by the broad Willamette Valley, which is in itself a series of connected valleys.

The term "Blue Mountains" is rather loosely applied to a group of irregular mountain masses covering much of the northeastern quarter of the State, but in that quarter there are some broad valleys and much rolling agricultural land.

The southeastern quarter of the State is largely a great plateau, 4,000 to 5,000 feet above sea level, but from this plateau several mountain groups rise, and there are several lakes, mostly shallow and brackish, which have some local effect on climate. There are a few deep canyons, but streams are few and mostly small, losing themselves in flats or marshes, or emptying into lakes having no outlets.

The Japan current has long been given unwarranted credit for the mild climate of western Oregon. However, the marine influence is the prime factor in the control of temperature west of the Coast Range, an important though less evident factor in the Willamette and other western valleys, and a less important but noticeable factor east of the Cascades.

Fortunately in the latitude of Oregon westerly winds predominate, and therefore the modifying effect of the ocean is greater than it would be otherwise. On the rather rare occasions when strong east winds blow the continental influence may extend to the coast. Such occasions are all the more noticeable because they are unusual.

Considering only places where reliable records have been kept, the normal annual temperature ranges from about 56° in the lower Snake River Canyon, in the extreme northeast, to about 38° in the high Cascade Mountains. There are of course areas higher than any of the meteorological stations, which have still lower temperatures.

As shown at recording stations, the range in annual temperature is greater than that found in going from Mobile, Ala., to Boston, Mass., or along the immediate coast from California to Alaska. The mean temperature of the warmer sections is like that of northern Texas, while that of the cooler portions compares with that of extreme northern Montana. In all parts of the State there are marked local differences in temperature. Even within the city limits of Portland there are found, at times, pronounced differences in temperature within a few blocks.

While these differences in normal annual temperature are striking, a description of them falls very far short of telling the whole story of temperature distribution. For example, Brookings, in the southwestern corner, and Pendleton, near the northeastern corner, have the same normal annual temperature, but at no time in the year are conditions at the two places similar.

Comparison of the normal minimum temperatures for January gives a measure of the relative severity of the

winters. While there is a range of about 18° in the normal annual temperatures in different parts of the State, the range in normal minimum temperatures for January amounts to more than 28°, or from 12° to 40°. The mildest winter nights are found on the southern coast, as is to be expected, but the greatest of extremes of cold are not in the mountains but over the high plateau regions, where the air is dry, air drainage rather poor, and conditions favor rapid cooling by nocturnal radiation. There are many local irregularities in the distribution of minimum temperature which cannot be shown on a map, but there are some which are sufficiently prominent to be quite noticeable. It has already been stated that the southern end of the Coast Range is higher than the northern, and that these Coast and Cascade Ranges are partially connected. This condition, together with high mountains in northern California, creates a temperature shadow to the east of the southern Cascades, where low minimum temperatures are common. The writer has seen Upper Klamath Lake entirely frozen over when some of the smaller lakes farther north, near the summit of the Cascade Mountains, were free from ice. A rather mild belt extends along the middle reaches of the John Day River, probably caused in part by foehn conditions. Another mild belt is in the vicinity of Summer Lake. This lake is shallow and would seem unimportant meteorologically, but peaches are grown in coves in the mountains west of the lake, at an elevation of about 4,500 feet.

Summer maximum temperatures show a still wider variation than winter minima. The coolest summer days are on the middle and southern coast. This is due largely to the direct cooling effect of the ocean, which is particularly cold in summer along the southern Oregon and northern California coast. A secondary cause is the prevalence of fog and clouds, which retard the diurnal rise in temperature. The highest temperatures in summer afternoons are along the middle reaches of the Columbia River, in the extreme north, and in the deep canyon of the lower Snake River, in the extreme northeast. The range of normal maximum temperature in July is from about 65° to 95°, which is greater than that for the entire United States east of the Rocky Mountains.

As an example of the contrast in temperature distribution in different parts of the State the following may be cited. In the year 1921 the highest temperature at Newport was 70° and the lowest 18°, making a range of 52° for the year. At Blitzen in that same year the maximum was 103° and the minimum was −50°, making a range of 153°. At Blitzen on August 22 of that year the maximum was 99° and the minimum 33°, making a range for the day of 66°, exceeding the annual range at Newport by 14°.

At certain times the temperature differences over the State are much more pronounced than would be indicated by reference to mean values. On July 30, 1929, which was a particularly hot day, the maximum at Brookings was 63° and at Pittsburg Landing, in the Snake River Canyon, 111°, making a range of 48°.

If often happens in summer that high temperatures in the interior are attended by low temperatures on the coast, and this calls to mind a current saying to the effect that hot spells in the Willamette Valley never last more than 3 days. This is not altogether true, but in the last 40 years there have been but eight times when the temperature at Portland has reached 90° for more than 3 days in succession. The average duration of such periods is 2 days. Persistence of high temperature in the interior of western Oregon for 2 or 3 days usually results in the northward extension of the Arizona LOW into Oregon; this in turn is followed by an indraft of cool air from the ocean which marks the close of the hot period. In southern Oregon, where the Coast Range is higher, warm periods last longer and maxima are higher. East of the Cascades warm periods are more persistent.

Under extreme conditions in winter temperature differences over the State may be even more pronounced than in summer. On January 21, 1930, one of the coldest days ever known in Oregon, the minimum temperature ranged from 38° at Brookings to −52° at Danner, a total range of 90°. In such times the lowest temperatures are usually in the open valleys and over the plateau.

Such extremely cold weather occurs only as the result of the rapid southward movement of an Arctic HIGH into the plateau region. This movement is attended by a marked fall in temperature, particularly in eastern Oregon. Extremely low temperatures occur a few days later, when the Arctic air is still further cooled by radiation. Such movements are attended by strong east winds through the Columbia River Gorge, but these east winds in winter are shallow, and as a rule do not cross the Cascade Mountains in any great volume. It might be expected, therefore, that the lowest minimum temperatures in western Oregon would be experienced near the mouth of the gorge, but this is not the case. In this instance the lowest minima were in the Williamette Valley, about 55 miles south of Portland, and in the Tualatin Valley, about 30 miles west of Portland. Still lower minima were recorded on lowlands along the Columbia about 50 miles north of Portland, on the Washington side. The cold air which comes through the gorge under these conditions is moving rapidly and there is little opportunity for the formation of marked temperature inversions until the air has spread out and become quiescent. As soon as it does become quiescent there is a rapid nocturnal fall in temperature near the ground, for this continental air is dry, and the sky is usually clear.

On the break-up of a cold period conditions are somewhat reversed. When warm south winds begin to blow over western Oregon following a cold snap there is usually still a slow drainage of cold air through the gorge for a day or two. The warm current overrides this cold air at first, and Portland will remain cool when normal temperatures have been reestablished to the north as well as to the south. Under extreme conditions south wind has been observed at the tops of some of the tall buildings while the wind in the streets was still from the east.

Mention has already been made of the fact that the cold east winds are shallow. Under certain pressure conditions these shallow cold winds may be overrun by great masses of warm, moist air, so that higher temperatures prevail in the mountains than in the valleys. An extreme condition of this kind was observed in November 1921 when there were heavy warm rains at high levels in the Cascades, with a noticeable decrease in snow cover, while sleet was falling and ice was forming in and near the Columbia Gorge.

When high-pressure areas move in from the Pacific and become established over the Plateau region, they cause cold weather in eastern Oregon, but extremes are much less pronounced than in the case of the southward movement of Arctic HIGHS. The plateau HIGHS often remain nearly stationary for considerable periods. This was particularly true in December 1930 and during that month temperature in eastern Oregon, while not extremely low at any time, averaged much below normal. The deficiency reached 7° along the eastern boundary.

A large part of the area west of the Cascades had temperature near or above normal, and instead of the cold weather of eastern Oregon extending through the gorge into the western portion the reverse seems to have been true, for a number of places along the Columbia River east of the Cascades had temperature slightly above normal.

It is difficult to determine the length of the growing season in the colder parts of Oregon, for over those regions agriculture is mostly confined to the growing of the hardier crops; moreover, in regions where the nights are so uniformly cool even the less hardy crops seem to develop a degree of resistence to frost. The records of killing frost show that over most of the region west of the Cascades the length of the growing season is more than 150 days, reaching 250 days on the coast. In the principal agricultural districts east of the Cascades it is between 100 and 200 days. Some of the high plateau districts have less than 50 days, and there are regions where frost may occur in any month of the year. However, even in these regions considerable areas are devoted to agriculture, and even some potatoes and garden vegetables are grown.

A preliminary study of the frequency of temperature changes in different parts of the State has given some interesting results, and it is planned to continue these studies as opportunity offers.

At Portland the changes from one 5 a.m. observation to the next are mostly very small. There is little chance of a verifying change and no chance at all of a verification of a cold-wave warning. In the last 10 years the extreme change has been 21°, and this was a plus change; 95 percent of the changes have been less than 10°.

The changes from one p.m. observation to the next at Portland have been somewhat greater, but even here in the last 10 years 88 percent of the changes have been less than 10°, with an extreme of 32°. The greater p.m. changes are quite largely the result of the passing of brief warm periods in summer, and are not the result of the passing of cyclones with well-defined warm and cold fronts.

At Baker, fairly representative of eastern Oregon, the data for the 5 a.m. observations for the last 10 years show a much greater prevalence of large changes. Many of these changes occur in winter, but they may occur at any time. Conditions at Baker are often favorable for rapid cooling by nocturnal radiation, and the local topography favors marked inversions. Because these temperature changes are so largely local they are rather hard to forecast.

Data for the 5 p.m. observations at Baker show a still greater probability of large changes, particularly minus changes. Many of these large changes occur in summer.

No discussion of Oregon temperature would be complete without reference to humidity in its relation to temperature. In the nature of things hot weather in Oregon must be dry weather. Low humidity is the normal summer condition east of the Cascades; extremes of heat west of the Cascades occur only when warm dry air is brought from the interior. For example, in August 1930 which was an unusually warm month at Portland, the reading of the wet thermometer at the 5 p.m. observation did not exceed 70° at any time. The fact that warm periods are also dry renders them less uncomfortable than they otherwise would be.

On the other hand, such cold periods as occur in western Oregon in winter are more noticeable because they are dry. This is particularly true near the mouth of the Columbia Gorge, where cold weather is usually attended by drying east winds, which are in marked contrast to the usual mild, moist winds from the ocean. For example, on the unusually cold day already referred to, January 21, 1930, the relative humidity at Portland was 40 per cent, as compared with a normal of 87 per cent.

In ordinary winter weather at Portland humidity is sufficiently high to simplify the matter of conditioning air in residences and public buildings. The same statement holds true over most of the State, though in a less degree in eastern districts.

A good deal is said from time to time about progressive variations in temperature from year to year. Portland has a complete record for nearly 60 years; the record for Roseburg covers more than 53 years, and that for The Dalles, though somewhat broken in early years, is nearly continuous for the last 56 years. Walla Walla and Boise, just outside the boundaries of the State, have somewhat longer records than Portland, though at Boise part of the records were kept at the military post, just under the foothills, and for this and other reasons may not be strictly comparable with the records now being kept in the city proper. These five records show fair agreement with one another. The most pronounced features are two warm periods, the first culminating in the early seventies and the second about 1926, and two cold periods, the first culminating about 1879 near the coast and about 1883 near the eastern boundary, and the second, somewhat less pronounced, about 1894.

It is generally conceded that as cities grow up around meteorological stations the recorded temperatures are somewhat too high. If this is true it would be expected that the Portland record would show some tendency toward higher temperature in the later years, as compared with records kept in smaller cities. It is found, however, that the later warm periods are quite as pronounced at other places as at Portland. There is very little in the records for any of the stations to indicate a progressive change in temperature.

THE SUMMER NIGHTTIME CLOUDS OF THE SANTA CLARA VALLEY, CALIF.

By EDWARD H. BOWIE

[Weather Bureau Office, San Francisco, Calif., 1933]

The decision of the United States Navy to make its Pacific coast base for airships in the Santa Clara Valley, Calif., in the vicinity and slightly to the north of the Weather Bureau station in San Jose, at a point known as Sunnyvale, is of particular interest to American meteorologists. Apparently this decision was reached only after an extended survey of this and other proffered sites for a Pacific coast base. What the findings and recommendations of the aerologists who made these surveys are is not known to the writer. It is to be assumed, however, that they were aerologically favorable to it, and doubtless led to the decision to recommend the Santa Clara Valley site. This site having been selected, it follows that any information concerning the climate and the day-to-day regime of weather in the vicinity of Sunnyvale base cannot fail to be of interest to the climatologist and to the meteorologist.

This study has been restricted to the daily regime of cloudiness in the summer months in the vicinity of San

Jose, as it will not be possible in the short space available to present many of the known and interesting facts concerning the climate and weather of the Santa Clara Valley.

The Santa Clara Valley is flooded of summer afternoons by highly humid air of marine origin, 1,000 to 1,500 feet deep, roughly. Above this marine air there is a stratum of undetermined thickness of much less vapor content and also warmer in its under portion, as shown by the aerographic flights made in the vicinity of Sunnyvale. The origin of this drier stratum of air is not definitely known, though it occurs widely along the California coast in the summer months.

The following are typical of these airplane logs.

11:05 A.M., JULY 31, 1931

Altitude	Pressure	Temperature	Relative humidity
Meters	*Millimeters*	° *C.*	*Percent*
Surface	759	20.0	66
503	713	14.4	77
1,204	657	23.0	12
1,575	630	21.2	18
1,910	606	19.0	11
3,261	516	14.2	0

NOTES.—At take-off few scattered Stratus clouds, bases 488 meters. Dense haze from surface to 914 meters. Thick bank of Stratus along the coast, tops about 2,438 (sic) meters.

9:51 A.M., AUG. 7, 1931

Altitude	Pressure	Temperature	Relative humidity
Meters	*Millimeters*	° *C.*	*Percent*
Surface	762	22.0	59
300	736	17.5	72
1,321	654	23.5	6
2,972	538	10.9	18
3,282	517	8.9	22

NOTES.—At take-off sky was cloudless. Moderate haze from surface to 488 meters. Light haze to southeast above 488 meters. Observed a few Alto Stratus clouds to the east from 914 meters. Thick bank of fog along the coast. Visibility improving during flight.

9:53 A.M., SEPT. 2, 1931

Altitude	Pressure	Temperature	Relative humidity
Meters	*Millimeters*	° *C.*	*Percent*
Surface	762	16.8	76
396	728	12.8	81
742	699	19.8	34
1,219	662	23.0	21
2,022	604	19.0	15
3,343	515	10.0	22

NOTES.—At take-off eight tenths Stratus from the west, base 183 meters, top 488 meters. Moderate haze from 488 meters to 1,524 meters. Base of inversion 518 meters. Thick bank of Stratus along the coast. Clouds dissipating rapidly during flight.

Stratus clouds form over the Santa Clara Valley nightly during the summer whenever it is flooded by marine air and the layer next above is warm and dry. These clouds commonly form at a relatively high altitude. i.e., near the upper surface of the stratum of marine air, and subsequently grow downward, as established by the hourly observations of the height of the ceiling over the Oakland Airport. Although observations of the height of the ceiling show unmistakably its descent during the nighttime after the first appearance of the stratus cloud, yet undoubtedly there are times when the cloud grows both upward and downward from the altitude where the condensation first began. These clouds presumably are not due to turbulence since they form when the wind movement within the stratum of marine air is at its diurnal minimum. Moreover, eye observations show that there is little or no horizontal movement of the air within the cloud layer. There is, however, much convective turbulence within the stratum of marine air when its lapse rate exceeds the adiabatic. The top surface of the stratus clouds then indicates the existence of vertical movement and the pilots of planes experience bumpiness within and below them.

The actual origin of these clouds appears to be the excess of emitted over absorbed radiation. It is known that air rich in water vapor is selectively highly absorptive of terrestrial or long-wave-length radiation; and being a good absorber it also is a good radiator in the same spectral region, in fact as good, nearly, as a black body. Conversely, dry, clear air is diathermanous to terrestrial or long-wave-length radiation and therefore in that region a nonradiator, and its temperature subject to change only by work done by it or upon it. Hence at night the stratum of marine air rich in water vapor cools radiationally while the stratum of dry air above it remains at a constant temperature or, at most, loses its heat very slowly. The truth of this statement is proven by the marked cooling of the earth's surface at night, when the overlying air is still, while the air itself is cooling but little, except near the ground, and there by contact with the cold surface.

From the foregoing, the conclusion is reached that the formation of stratus clouds over the Santa Clara Valley during the summer is to be regarded as a radiative phenomenon, occurring when the valley is flooded by air of marine origin, rich in water vapor, and when it in turn is overlain by air of quite low humidity. When this situation exists the excess of outgoing over incoming radiation is at its maximum at the upper surface of the bay of marine air, and sometime during the night the cooling thus caused reaches the dew point, condensation starts and cloud forms. It does not necessarily follow that the dew point is reached first at the upper surface of the humid air; it may be at some intermediate altitude between this surface and the bottom. When the dew point is reached at the upper surface first, the growth of the cloud is downward; whereas when it is reached first at an intermediate altitude the growth of the cloud is both upward and downward. Ultimately the cooling throughout the marine air, from a maximum at its upper surface downward to a minimum at its bottom, may result in the lapse rate exceeding the adiabatic, when there will follow convection and turbulence that would cause a pilot passing through or under the cloud to experience bumpiness. This convective turbulence increases the rapidity of cloud formation. The descending currents, the counterparts of the ascending currents in the convective process, are not heated at the adiabatic rate for dry air, for in them there is a loss of heat by evaporation, the equivalent of that gained by condensation in the ascending currents. As the cooling proceeds the thickness of the cloud increases and at times the entire mass of marine air is filled with cloud from top to bottom.

SOME ASPECTS OF FREE-AIR WINDS IN THE FAR WEST

By Thomas R. Reed

[Weather Bureau Office, San Francisco, Calif., June 1932]

At the beginning of the present year (1932) a noteworthy improvement was made in the system of reporting and collating the results of pilot-balloon observations in the United States. Previously the datum point for each wind level reported had been the level of the observing station instead of a common level. Since January 1932 a common level has been used, namely, sea level. The result is greater uniformity, or at least, greater consistency, of the reported data. Doubtless the effect of the change was most appreciated by users of the data in the Far West where the mountainous character of the terrain produced a marked "staggering" of levels under the old system.

Take, for example, the reported data for a given level, say 4,000 m. In the past such data in the form available for entry on the aerological charts actually approximated wind conditions at that height above those stations only which were situated near sea level. For elevated stations such, let us say, as Reno, Salt Lake City, or Rock Springs, the data, ostensibly for the 4,000-m level, actually represented wind movements at much higher levels, viz, 5,346 m, 5,294 m, and 5,953 m, respectively. Hence the forecaster, endeavoring to interpret the atmospheric situation in terms of air streams was constrained to make allowance for such inconsistencies in forming his estimate of the circulation factor so far as it was revealed by the wind-aloft reports. That the key to the meteorological situation is frequently contained in these reports is beyond argument; hence the importance attaching to their accuracy can hardly be overstated.

Pilot-balloon runs as an aid to forecasting have been systematically made in the Far West since their inauguration at San Francisco about 12 years ago. The Army and Navy added their cooperation soon after with runs at San Diego, Sacramento, and Camp Lewis, and the Weather Bureau later on added other stations to the list, but a complete network of pilot-balloon stations was not realized west of the Rocky Mountains until the Airways Weather Service came into existence with its elaborate program of upper-air soundings in behalf of aviation. These observations, primarily designed as an aid to aerial navigation, have been of great value in the work of weather forecasting, too. To the forecaster they are an invaluable guide in his day-to-day tasks, and in addition they have an educational aspect that is not to be ignored. They serve to disabuse him of incorrect opinions that he may have entertained, and to enlighten him regarding atmospheric events of which he may have been unaware or perhaps only vaguely conscious.

An illustration in point may be found in the simple and well-known rule that southerly winds (on the Pacific slope) bring rain. This precept shows deference to the formal requirements of widely accepted ideas such as the "warm front" and "convergent current" hypotheses. Both postulate a southerly current near the surface in front of eastward moving cyclones, and both of course assume it to be composed of rising air. In one view the southerly current ascends by reason of overrunning a wedge of colder air in its path; while the other view supposes ascension to result from convergence of lines of flow in the southerly current, itself. Touching the latter, Shaw is not sure whether the convergence is the cause or the result of the ascending current but is "content to know that convergence cannot occur unless there is an upward current to take off the air." [1] The absence of a cold wedge (east wind) in advance of cyclone centers off our west coast is a fact of common observation. The surface temperatures in the region of the broad rain band are mild and remarkably uniform, and winds everywhere from a southerly quarter except where required by topography to be otherwise.

In the Bjerknes theory the south wind is not a rain wind until it leaves the surface and rides up over a denser westward flowing current athwart its path. Hence this theory fails to account for the fact that a southerly surface wind is a rain wind on the Pacific coast. As for the alternative possibility—convergence—the balloon observations fail to reveal it at all. Aerological data show that a southerly surface wind is a rain-bearing wind only in the sense that it may and often does imply a west or southwest wind aloft—a fact which points to the conclusion that reduction of pressure aloft and consequent upwelling of the lower strata, rather than convergence of air streams below, is responsible for the ascent of air in the rain-making sector of the warm front. They seem to support with a good deal of consistency the view that the apparent vortex and inflowing winds of the lower cyclone levels are incidental to divergent air streams aloft, one flowing down from the north, and the other flowing up from the south *and veering toward the east with increase of altitude*.

It is in this region of divergence that the pressure falls, because it is in this region that air is being evicted by the eastward-veering winds aloft. Hence it is superfluous to appeal to convergence or to topography for the explanation of the ascension of the southerly surface air; it is compelled to rise by the eviction of air aloft. That topography plays an important (though far from all important) part in rain production on the Pacific coast is admitted, but if we look to topography alone for an explanation of the rain-making propensities of the southerly wind we shall err, for southerly winds run parallel to the main mountain ranges instead of counter to them, so that unless the winds above are turning toward the east, a southerly wind, by reason of the deflective force of the earth's rotation, brings about a rise in pressure along the west side of the mountain ranges instead of bringing about a fall. Furthermore, reports from ships at sea show the southerly wind to be a rain wind but without the circumstance of topography to aid it; the veering or divergence aloft of the two principal air streams involved is sufficient in itself to account for the observed phenomenon of rising air and rain.

It has often been observed that when the south wind does not veer toward the east aloft, the pressure falls very slowly, if at all, and rain is a rare consequence. This observation has so few exceptions as to make the following precept worthy of consideration, namely, that not convergent but divergent winds (in the upper levels) are an essential of the rain-making process in front of Pacific Ocean LOWS. Or, to put it more exactly, but still in general terms, the commonest type of rain-making regime on the Pacific coast requires on the west side of the cyclone a more of less "solid" northwest or north-northwest current up to considerable altitudes, and on the east side of the cyclone a southerly current that diverges toward the east with increase in height.

[1] Shaw, W. N. Forecasting Weather, 2d edition, p. 241.

Also, the proverb that a south wind brings rain, might well be supplanted by the more accurate statement that it is the west wind which brings the rain; for both the rain and the southerly surface wind which attends it are, in a sense, by-products of the falling pressure for which the westerly current aloft is directly accountable.

While the foregoing applies with fewest exceptions to elliptical or trough-shaped depressions, it is germane to depressions of nearly all types, provided they are of large area. It does not seem to apply to many small depressions which sometimes form over the Far West and which present the aspect of a vortex up to the highest level sounded by the aerological net, viz, 14,000 feet. Counter currents do not appear to be accountable for their formation or maintenance; at least none are evident up to the height mentioned. What transpires above is conjectural, but the fact that the cyclonic circulation in such cases is always observed at the high levels prior to the development of falling pressure and unsettled weather at the surface certainly points to the general hypothesis that cyclones of the Far West are of high level origin, although it does not explain how those which appear as a vortex at 14,000 feet above sea level were generated.

But not all small depressions present a vortical circulation aloft. Those, for example, which sometimes appear off our southern coast are also often conspicuously identified with west or southwest winds in advance of them, i. e., over Arizona and New Mexico, but instead of the air current in their rear being from the northwest or north-northwest as in the case of large eastward moving cyclones of higher latitudes, the free-air winds are often from the north-northeast. Cyclones of this type are accompanied by high pressure at sea to the northward, the main axis of the anticyclone lying in a northeast-southwest direction with the cyclone on its equatorial side. It is important to note that so long as the upper winds in the northeast quadrant of such a cyclone continue to blow from the northeast or north-northeast, the disturbance lingers off the southern California coast (either the original one or a successor); whereas as soon as the winds referred to lose their east component and veer to the north and northwest, the cyclone moves eastward and the weather in southern California clears.

Mr. R. H. Weightman, whose helpful comments on this paper when in manuscript form deserve acknowledgment, remarked in this connection that "European writers have found, and it has been substantiated by our studies here (Washington, D.C.) that the movement of LOWS is more directly associated with air currents between 500 m and 2,500 m in the eastern half of the LOW, than with those in the western half, especially when the LOW has a warm sector." This is precisely what one would expect of low-level cyclones moving over a not too mountainous terrain. For our ultramountainous West it does not apply, and forecasters in the Far West are compelled to depend on wind data around the 4,000 m level for the most reliable clues of storm travel.

Examples like the foregoing, illustrative of the part played by the two great air streams—the north and the west—merely stress familiar facts, but facts important enough, perhaps, to bear repetition, and whose reiteration may even now be helpful in stressing the fact that it is the flow of air currents and their interaction which are our primary concern, rather than surface phenomena. In the "great rivers of air" over our heads, to borrow an expression of Maj. E. H. Bowie, is to be found the answer to the weather forecaster's most pressing problems; and while these rivers are often to be inferred from the isobaric patterns on the synoptic charts, the balloon data frequently serve to bridge over the inferential gap and acquaint the forecaster directly with much that he needs to know.

In the plotting and anticipation of these rivers of air, so important to the success of short-period weather forecasting, must we not ultimately find, if it is found at all, the key to the greater problem of long-period forecasting? Weather types are essentially air-flow types, and the persistence of a weather type is consequent upon the persistence of an air-flow type. The recent cold and snowy winter (1931–1932) in the Pacific States is an example. It was prolific of depressions which appeared in the far North or Northwest and moved southward along or near the Pacific coast. Obviously the controlling air currents, of which the depressions were peripheral phenomena, were persistently from a north or northwest quarter and constituted a very extraordinary south or southeastward movement of air over the northeast Pacific Ocean during the wettest part of the winter. A survey of synoptic charts and pressure graphs for this period confirms this inference in the persistence they show of high pressure offshore and low pressure over the far western portions of the United States and Canada. The Pacific coast seemed, much of the time, to lie in a "low-pressure lane" created and maintained by the southward flowing aerial river immediately to the westward.

In contrast to this was the excessively dry fall and winter of 1929–30. During the dry part of the period the reverse of the foregoing situation with respect to air streams evidently prevailed. Charts and pressure graphs showed a marked preponderance of high pressure over the far western portions of the United States and Canada, and about the usual amount of low pressure, if not more, at sea—clear evidence of a dominating flow of air from the south or southwest along and off the Pacific coast, which prevented disturbances from moving inland and carried them northward instead. The "low-pressure lane", to the extent which any existed, lay necessarily on the west side of this current, leaving the Pacific States and British Columbia in a dry zone so long as the aerial river, which was responsible, persisted in the position and course described.

THE RELATION OF JUNE TEMPERATURE TO THE MATURING OF CORN IN IOWA

By CHARLES D. REED

[Weather Bureau, Des Moines, Iowa]

[Author's Abstract]

The extent of autumn frost damage in Iowa is largely determined by the mean temperature of the previous June. In every one of the 12 cases when the June mean temperatue was 2°, or more, above the average, 69.4°, during the 43 years from 1890 to 1932, 95 percent, or more, of the corn escaped frost damage.

In 21 years out of 22, with June mean temperature normal, 69.4°, or higher, the percentage of corn not frosted was greater than the 43-year average of 87.3 percent. Except in 1923, when 75 percent was not frosted, 90 percent, or more, escaped frost damage in all of the 22 years.

A June mean temperature of 67° (2.4° below the average of 43 years) roughly divides the years in which 90 percent, or more, of the corn matured safely, from those having the most serious frost damage. Thirty-two Junes had temperatures above 67°, and in 29 of them 90 percent, or more, of the corn escaped frost.

All of the outstanding years of frost damage had a June mean temperature below 67°. In the order of rank, the worst 5 years were 1924, with only 33 percent not frosted; 1915, 35 percent; 1902, 48 percent; 1917, 49 percent; and 1912, 66 percent. There were 11 years with June mean temperature below 67°, and in 9 of these more that the average amount of corn was frosted.

RAININESS CHARTS OF THE UNITED STATES

By Eric R. Miller

[Weather Bureau, Madison, Wis.]

Raininess is the average rainfall per rainy day, rainy day being defined in turn as one with 0.01 inch or more of rain or melted snow.

The average raininess of the United States for the 4 seasons and for the year is shown on the 5 charts accompanying this paper. The data from A. J. Henry, climatology of the United States (Bulletin Q, U.S. Weather Bureau) of average rainfall and average number of rainy days, were employed in computing the raininess because they appear side by side in that publication.

Data from both regular and cooperative stations were worked up, but the results from the cooperative stations proved to be too inconsistent for use on the charts. This inconsistence results from the large variation in the number of rainy days recorded by cooperative observers to which I have previously drawn attention (M.W.R. 43, 1915, 275–278). The difference between cooperative and regular stations is greater in winter than in summer. The following table contains a few of the more extreme cases noted in preparing these maps.

Comparative raininess at regular and cooperative stations.

Station	Winter			Summer			Year		
	Rainfall	Rainy days	Raininess	Rainfall	Rainy days	Raininess	Rainfall	Rainy days	Raininess
Baltimore, Md	10.0	34	0.29	12.7	33	0.39	43.4	131	0.33
Darlington, Md	10.5	18	.58	12.0	23	.53	43.8	82	.54
Jupiter, Fla	9.3	28	.33	16.6	39	.43	58.7	134	.44
Miami, Fla	8.1	9	.90	20.6	22	.94	58.3	65	.90
San Luis Obispo	10.3	19	.54	.1	0	------	19.2	42	.46
Santa Barbara, Calif	10.0	11	.91	.1	1	.10	16.6	27	.61
Springfield, Ill	7.6	29	.26	10.0	28	.36	37.4	117	.32
Griggsville, Ill	6.3	15	.42	10.9	19	.58	37.0	73	.51
Duluth, Minn	3.3	32	.10	11.6	37	.33	29.9	133	.22
Mount Iron, Minn	2.9	12	.24	13.8	26	.53	33.3	74	.45
North Platte, Nebr	1.3	15	.09	8.1	26	.31	17.9	79	.23
Ansley, Nebr	1.8	9	.20	10.3	21	.49	23.0	57	.40
Abilene, Tex	3.4	14	.24	7.0	19	.37	24.5	66	.37
Menardville, Tex	3.3	6	.55	6.9	10	.69	22.6	35	.65

Comparison of the maps of raininess with the maps of precipitation and of number of rainy days in the Atlas of American Agriculture, part 2, section A, Precipitation and Humidity, by J. B. Kincer, shows that raininess is more uniformly distributed than rainfall. This results from the fact that rainfall and number of rainy days tend to vary together, so that the result of dividing one by the other shows less fluctuation. The mountain maxima of rainfall do not appear in the raininess charts.

The number of rainy days is relatively greater in the Northeastern States than in the Southern. Hence the gradient of raininess from the Gulf States to the Lake region is somewhat steeper than the gradient of rainfall.

The annual march of raininess varies from the interior toward the oceans. In the interior the raininess is smallest in winter, but is then largest on the Pacific slope. The North Atlantic States have relatively uniform raininess throughout the year, but in the Gulf States winter and spring exceed summer and autumn.

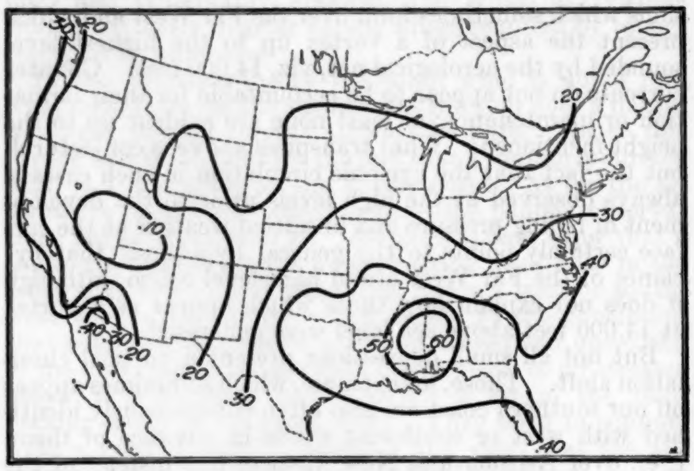

Figure 1.—Raininess chart of the United States—spring.

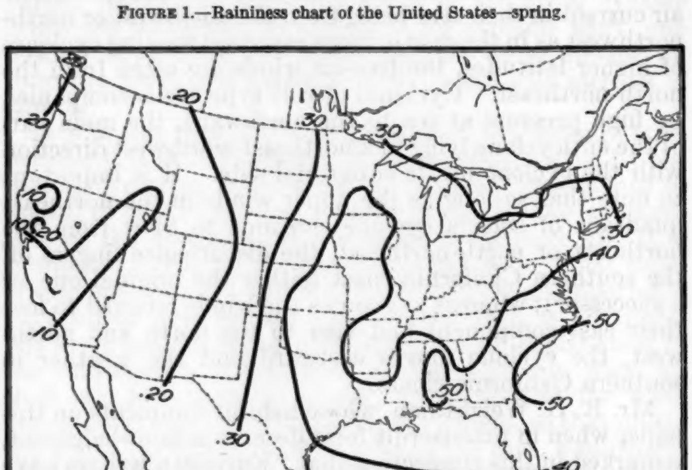

Figure 2.—Raininess chart of the United States—summer.

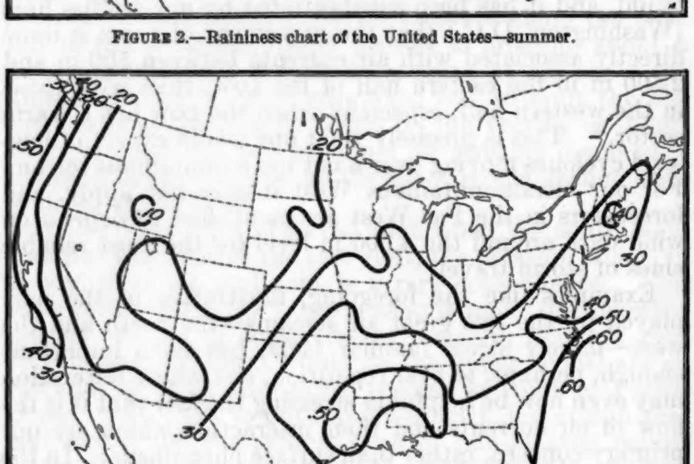

Figure 3.—Raininess chart of the Unitd States—autumn.

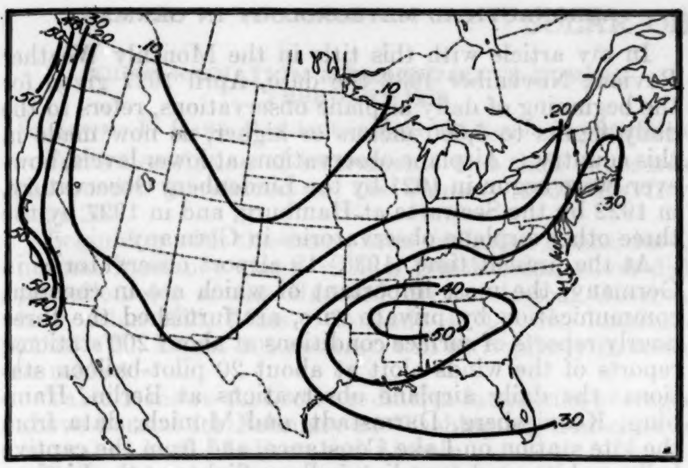

FIGURE 4.—Raininess chart of the United States—winter.

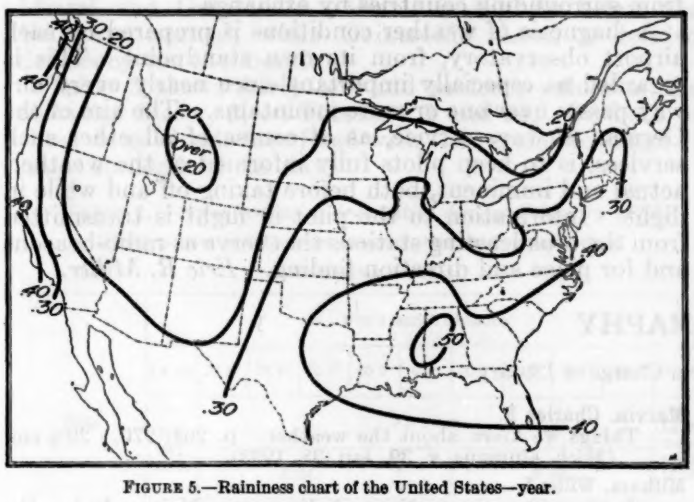

FIGURE 5.—Raininess chart of the United States—year.

The data used in charting the raininess end with the year 1903. In order to see if there has been any secular change, similar data have been taken out for five stations for the period ending with the year 1930. The results are given in the following table:

Comparative raininess

Station	To—	Winter	Spring	Summer	Autumn	Year
Boston	1903	0.32	0.32	0.34	0.37	0.34
	1930	.31	.31	.34	.36	.33
Chicago	1903	.19	.25	.35	.28	.27
	1930	.19	.25	.34	.29	.27
New Orleans	1903	.44	.55	.41	.43	.45
	1930	.46	.58	.43	.48	.47
Phoenix	1903	.25	.20	.16	.21	.20
	1930	.20	.25	.18	.24	.20
San Francisco	1903	.38	.25	.07	.31	.33
	1930	.40	.29	.06	.29	.33

THE ICE STORM OF DECEMBER 16–17, 1932, NEAR HIGHLANDS, N.C.

By L. T. PIERCE

[Weather Bureau office, Ashville, N.C.]

A glaze or ice storm of destructive severity visited several widely-separated localities in the North Carolina mountains on the night of December 16–17, 1932. Limbs and branches were stripped from forest and shade trees, and even trunks snapped off under the weight of the ice accumulations. The principal area of destruction extended from Highlands, N.C., northward along the Blue Ridge for a distance of 20 to 30 miles. Light glaze conditions prevailed over a much wider area, extending over the western half of the Carolinas, northern Georgia, eastern Tennessee, and probably into nearby States.

Apparently cold, northeast surface winds, moving nearly parallel to, but east of, the Blue Ridge were overrun by moist, warmer air from the south in which precipitation occurred in the form of rain that froze when it came into contact with the surface which previously had been cooled, by the northerly winds, to below the freezing point.

ORGANIZATION OF THE METEOROLOGICAL AND AEROLOGICAL SERVICES RELATIVE TO AVIATION IN CHILE

By JULIO BUSTOS NAVARRETE, Director

[Observatorio del Salto, Santiago, Chile, 1931]

Since 1927 aviation in Chile has relied on its own service to disseminate the meteorological and aerological information necessary to the navigation of the air.

In reality this service depends on three central observatories and numerous stations throughout the length of the land that make daily issues of weather information to the pilots.

The meteorological and aerological observatory at the aerial base Los Condores (Iquique) collects observations in the northern zone of Chile and transmits them daily, at 8 a.m. and 2 p.m., by radio to "El Bosque."

The meteorological and aerological observatory at the aerial base Maquehue (Temuco) collects observations in all of the southern zone and transmits them daily, at 8 a.m. and 2 p.m. to the station at "El Bosque."

The central meteorological office for aviation attached to the meteorological observatory at "El Bosque" collects, in its turn, all observations in the central zone.

As a result there are collected by radio at "El Bosque" at an early hour in the morning and at an early hour in the afternoon data on the state of the atmosphere throughout the country, with the observations necessary for the construction of meteorological charts relative to navigation of the air.

At each observatory records are made of atmospheric pressure, temperature, humidity, direction and force of the wind at the surface and also at different elevations, amount and classification of clouds, visibility, precipitation, and also of aerial soundings.

The instrumental equipment of the central observatories Los Condores, El Bosque, and Maquehue is very complete, including apparatus for direct reading and automatic registration. Furthermore, at El Bosque there is used for aerial soundings a Zeiss recording theodolite that traces in a diagram the direction and the velocity of the wind at different elevations.

Experiments are made with meteorographs installed on the planes of the Línea Aéria Nacional, and each pilot carries a route sheet on which are entered the meteorological conditions for each region of the country.

By means of this simultaneous study of the weather and the rapid centralization of meteorological observations by radio there is obtained a complete survey of the weather from one extreme of the Republic to the other.

Each day at noon the Oficina Meteorológica de la Aviación issues through the radio station El Bosque a meteorogram with information of the weather, and forecasts, for each zone of the country. The weather data are noted on blackboards and bulletin boards near the meteorological maps.

In addition to this regular service there is given to every pilot on request a meteorogram setting forth the state of the atmosphere along the proposed route at the time.

If a pilot must depart from Arica he collects information on the state of the atmosphere through radio in a very short time and can have an exact knowledge of the meteorological conditions that he will encounter.

Under the Dirección de Aeronáutica there is a Sección Meteorológica in charge of statistical data and meteorological observations at the aerial bases in Chile. Meteorological maps are drawn daily, the observations made on the route sheets are entered in graphs, the elaboration of aerial navigation charts is studied, pamphlets containing meteorological instructions to pilots are published, and studies of the meteorological conditions along each route are made public.

In the aviation school at El Bosque there is a 2-years course in meteorology for the proper preparation of pilots. (Translated by W. W. R.)

AERONAUTICAL METEOROLOGY IN GERMANY

In my article with this title in the Monthly Weather Review, November 1932 the date, April 1927 given for the beginning of daily airplane observations, refers to the daily flights to 5,000 meters or higher, as now made in this country. Airplane observations at lower levels, however, were begun in 1921 by the Lindenberg Observatory, in 1922 by the Seewarte at Hamburg, and in 1927 by the three other airplane observatories in Germany.

At the present time (1933) 19 airport observatories in Germany, the most important of which are in constant communication by private wire, are furnished the three hourly reports of surface conditions at about 200 stations; reports of the winds aloft at about 20 pilot-balloon stations; the daily airplane observations at Berlin, Hamburg, Koenigsberg, Darmstadt, and Munich; data from the kite station on Lake Constance, and from the captive balloon, kite, and sounding balloon flights at the Lindenberg Aeronautical Observatory; and observations received from surrounding countries by exchange.

A diagnosis of weather conditions is prepared by each airport observatory, from its own standpoint. This is regarded as especially important since nearly every airway passes over one or more mountains. The aim of the German airways service, as of course of all other such services, is to keep pilots fully informed of the weather, actual and imminent, both before taking off and while in flight. Information to the pilot in flight is transmitted from the broadcasting stations that serve as radio-beacons and for place and direction finding.—*Eric R. Miller*.

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SOLAR OBSERVATIONS

SOLAR RADIATION MEASUREMENTS DURING FEBRUARY 1933

By IRVING F. HAND, Assistant in Solar Radiation Investigations

For a description of instruments and their exposures, the reader is referred to the January 1932 REVIEW, page 26.

Beginning with this issue, solar radiation intensities at normal incidence taken with a Smithsonian silver-disk pyrheliometer at the Harvard Meteorological Observatory, Blue Hill, Mass. (latitude 42°13′ N., longitude 71°07′ W., height 195 meters), will be regularly included in table 1.

Table 1 shows that solar radiation intensities averaged above normal for February at Washington, and close to normal at both Madison and Lincoln.

Table 2 shows an excess in the total solar radiation received on a horizontal surface at all stations except Miami and Gainesville. Miami is slightly below the February normal, while Gainesville shows a decided deficiency for the month.

Table 3 shows fairly low and uniform values of the turbidity factor, β, on February 2 and 24. On both of these dates clouds interfered with the regular readings at times throughout the day.

TABLE 1.—*Solar radiation intensities during February 1933*

[Gram-calories per minute per square centimeter of normal surface]

Washington, D. C.

Date	8 a.m. 75th mer. time	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon Local mean solar time
		Sun's zenith distance									
		Air mass A.M.					Air mass P.M.				
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
	mm	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm
Feb. 2	6.02						1.15	0.93	0.76	0.63	5.36
Feb. 3	2.87		.91	0.99	1.29						2.49
Feb. 9	.96			1.26	1.41		1.31	1.17	1.00	.84	.86
Feb. 16	2.16			1.16	1.34						2.36
Feb. 21	3.45	0.87	1.02	1.19	1.38						1.78
Feb. 24	4.16	.46	.58	.75	.96						3.15
Feb. 27	1.78		.89	1.10	1.35		1.33	1.19	1.12	.97	1.88
Feb. 28	1.96		1.05	1.12	1.36		1.30	1.11			2.16
Means		.77	.91	1.08	1.30		1.27	1.10	.96	.81	
Departures		+.04	+.08	+.09	+.12		+.07	+.12	+.11	+.05	
Madison, Wis.											
Feb. 8	0.51									1.23	0.58
Feb. 10	.64		1.10								.96
Feb. 15	1.19		1.06	1.20	1.40						1.19
Feb. 17	1.45						1.29				2.06
Feb. 18	2.26			1.10							2.06
Feb. 20	3.00						1 36				3.63
Feb. 21	1.12		1.14								1.45
Feb. 23	4.16						1.36				3.81
Feb. 24	4.37			1.09							4.17
Feb. 28	3.63			1.05	1.28						3.00
Means			1.10	1.11	(1.34)		1.34			(1.23)	
Departures			+.02	−.09	−.02		−.02			+.12	

TABLE 1.—*Solar radiation intensities during February 1933*—Con.

Lincoln, Nebr.

Date	8 a.m. 75th mer. time	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon Local mean solar time
		Sun's zenith distance									
		Air mass A.M.					Air mass P.M.				
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
	mm	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm
Feb. 5	0.79		1.04	1.23	1.41	1.63					1.96
Feb. 10	.66						1.36	1.10	0.88	0.75	1.19
Feb. 11	1.07	0.94	.98	1.14	1.33	1.49					1.24
Feb. 12	2.16						1.34	1.15	1.00	.88	2.87
Feb. 14	1.37							1.25	1.15	1.04	1.88
Feb. 15	1.78	.79	.98	1.15	1.37	1.63					2.74
Feb. 17	3.15				1.39	1.59	1.44	1.30	1.16	1.06	2.74
Feb. 18	3.00	1.02	1.12	1.26	1.41	1.57					3.30
Feb. 21	3.45	.87	1.03	1.19	1.39	1.61					2.26
Feb. 23	2.26	.89	.99	1.13	1.36	1.63		1.13	.98	.89	3.99
Feb. 25	2.87				1.43	1.49	1.40	1.28	1.09	1.00	4.62
Feb. 28	3.15	.82	.93	1.04	1.23	1.40	1.23	1.03	.88	.77	2.74
Means		.87	1.01	1.16	1.37	1.56	1.35	1.18	1.02	.91	
Departures		−.04	±.00	−.02	±.00		±.00	+.01	−.01	−.01	
Blue Bill, Mass.											
1932											
Nov. 25	4.6				1.33						4.4
Nov. 27	1.6							1.21	1.16		1.7
Dec. 3	7.0							.81	.73		6.9
Dec. 5	3.9			1.00							3.8
Dec. 8	3.2		1.13	1.27	1.42						2.5
Dec. 9	2.2			1.05				1.03			3.2
Dec. 16	1.1		1.20	1.34	1.49			1.28	1.17		1.2
Dec. 22	2.9							1.11	1.02		3.0
Means			(1.17)	1.16	(1.46)			1.06	.97		
1933											
Jan. 1	3.6			1.32				1.29	1.16	1.05	3.6
Jan. 5	3.1		.85	1.07				1.14			2.6
Jan. 6	1.1							1.18			1.5
Jan. 10	1.3			1.34				1.13			1.3
Jan. 15	5.2			1.14							3.4
Jan. 18	3.9			1.18	1.40			1.21			3.6
Jan. 21	3.4							.90			4.2
Jan. 23	4.4							1.19	1.03		4.5
Jan. 24	3.6		1.06	1.20				1.20	1.06		2.0
an. 30	3.2			1.19			1.32	1.19	1.00		3.4
Jan. 31	3.1		1.03		1.37		1.38	1.18	1.01		3.3
Means			.98	1.21	1.39		1.35	1.16	1.05	(1.05)	
Feb. 1	3.8	0.65	.79	.97	1.20	1.47					3.7
Feb. 2	6.6	.75	.88	1.02	1.22	1.50	1.19				5.4
Feb. 3	3.1					1.44	1.23	1.05	.90	.78	3.2
Feb. 9	.9	.98	1.13	1.30	1.43	1.53	1.33	1.20			1.4
Feb. 10	1.3			1.03	1.22	1.46					1.2
Feb. 12	1.4			1.28	1.45	1.63	1.43				1.2
Feb. 13	2.0	.80	.92	1.06	1.21	1.38					3.3
Feb. 16	1.7			1.27	1.38	1.50					2.2
Feb. 18	3.8				.76		.88				3.6
Feb. 19	3.2				1.01		1.23				4.0
Feb. 22	3.4				1.28	1.38	1.21				4.2
Feb. 23	4.6					1.32	1.15	.96			4.4
Feb. 24	3.0				1.27		1.29				2.9
Feb. 27	2.8				1.28		1.32				2.6
Means		.80	.93	1.13	1.23	1.46	1.23	1.07	(.90)	(.78)	

* Extrapolated.

Polarization measurements made on 6 days at Washington give a mean of 52 percent with a maximum of 56 on the 9th. These are slightly below normal for the month. No polarization readings were obtained at Madison due to the continued presence of ice and snow.

TABLE 2.—*Average daily totals of solar radiation (direct+diffuse) received on a horizontal surface*

Week beginning—	Washington	Madison	Lincoln	Chicago	New York	Fresno	Pittsburgh	Fairbanks	Twin Falls	La Jolla	Gainesville	Miami	New Orleans
	Gram calories per square centimeter												
1933	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.	Cal.
Jan. 29	236	143	246	124	188	245	115	14	222	254	124	349	149
Feb. 5	204	246	290	222	205	362	178	31	249	268	130	320	188
Feb. 12	232	255	335	198	218	284	201	68	311	315	195	382	228
Feb. 19	308	262	380	269	231	417	226	123	270	309	264	372	232
	Departures from weekly normals												
Jan. 29	+37	−44	+18	+6	+45	+14	−5		+27	±0	−125	−3	
Feb. 5	+92	+38	+36	+90	+57	+94	+27		+19	+14	−143	−43	
Feb. 12	+6	+26	+50	+46	+52	−28	+24		+41	+36	−115	+11	
Feb. 19	+49	+10	+71	+89	+35	+63	+85		−12	−12	−79	±0	
	Accumulated departures on Feb. 26												
	+1,736	−420	+1,281	+2,331	+2,142	+294	+1,120		−96	−399	−5,523	−840	

TABLE 3.—*Solar radiation measurements, and determinations of atmospheric-turbidity factor, β, Washington, D.C., February 1933*

[Values in italics have been interpolated]

Date and solar hour angle	Solar altitude, *h*.	Air mass, *m*.	I_m	I_y	I_r	β	Blueness of sky	Atmospheric dust particles per cubic centimeter	Notes: Skylight polarization, P., clouds, etc.
Feb. 2			gr. cal.	gr. cal.	gr. cal.				
0:18 a	34-11	1.78	1.248	*0.936*	0.755	0.065		699	
0:13 a	34-09	1.78	1.244	.936	*.755*	.068			
1:24 p	30-56	1.94	1.148	.826	.661	.055			
1:30 p	30-22	1.96	1.155	*.818*	.655	.050	5		P=53.7.
3:34 p	15-08	3.79	.768	.570	*.424*	.040			
Feb. 3									
3:33 a	15-33	3.70	.879	*.756*	.641	.085		586	
3:25 a	16-48	3.43	.948	.764	*.644*	.065			
3:20 a	17-33	3.34	.954	*.770*	.647	.065			
3:08 a	19-18	3.03	.976	.779	*.656*	.070			
Feb. 8									
1:47 a	30-27	1.96	1.309	*.938*	.749	.020	5	479	P=55.2.
1:42 a	31-36	1.90	1.306	.943	*.743*	.020			
0:49 a	34-52	1.75	1.233	*.923*	.718	.020			
0:44 a	35-09	1.70	1.301	.921	*.714*	.023			
Feb. 9									
1:15 a	33-37	1.80	1.416	1.058	*.850*	.030		420	
1:11 a	33-58	1.79	1.431	*1.058*	.850	.025			
0:31 a	35-58	1.70	1.448	1.060	*.861*	.030			
0:26 a	36-06	1.69	1.459	*1.058*	.862	.025			
1:39 p	31-26	1.92	1.331	.982	*.797*	.035	6		P=56.3.
1:42 p	31-22	1.92	1.333	*.979*	.797	.035			
2:53 p	23-12	2.53	1.249	*.905*	.727	.020			
2:59 p	22-07	2.65	1.236	.900	*.721*	.020			
3:27 p	17-54	3.24	1.143	.844	*.698*	.020			
3:33 p	17-45	3.26	1.129	*.838*	.688	.020			
3:43 p	15-23	3.74	1.049	*.783*	.673	.030			
3:47 p	14-45	3.89	1.024	.779	*.662*	.030			
Feb. 16									
3:46 a	16-16	3.54	1.102	*.761*	.745	.040		284	
3:42 a	17-16	3.34	1.108	.858	*.749*	.045			
3:28 a	19-30	2.98	1.160	.904	*.753*	.040			
3:23 a	20-18	2.86	1.204	*.906*	.754	.035			
2:48 a	25-32	2.31	1.294	*.970*	.707	.030			
2:43 a	26-14	2.26	1.304	.970	.705	.030	4		P=50.2.
1:17 a	35-40	1.71	1.378	*.974*	.788	.025			
1:13 a	36-00	1.70	1.371	.974	*.785*	.025			
1:09 a	36-18	1.69	1.388	*.971*	.764	.020			
1:00 p	38-40	1.60	1.473	*1.012*	.842	.020			
1:08 p	38-30	1.61	1.475	1.011	*.841*	.020			
1:24 p	36-52	1.67	1.440	*.993*	.792	.020			
1:28 p	36-32	1.68	1.440	.991	*.791*	.020			
1:47 p	34-45	1.74	1.414	*.983*	.782	.020			
1:50 p	34-24	1.76	1.402	.982	*.779*	.020			
Feb. 24									
3:39 a	19-46	2.94	.779	*.620*	.512	.100		420	
3:36 a	20-22	2.86	.795	.617	*.514*	.095			
3:08 a	24-51	2.37	.888	.671	*.547*	.090			
3:03 a	25-34	2.31	.901	*.668*	.549	.085	4		P=49.2.
1:05 a	39-20	1.58	1.056	*.732*	.567	.070			
1:01 a	39-36	1.57	1.066	.733	*.568*	.065			

TABLE 3.—*Solar radiation measurements, and determinations of atmospheric-turbidity factor, β, Washington, D.C., February 1933*—Continued.

Date and solar hour angle	Solar altitude, *h*.	Air mass, *m*.	I_m	I_y	I_r	β	Blueness of sky	Atmospheric dust particles per cubic centimeter	Notes: Skylight polarization, P., clouds, etc.
Feb. 28									
4:29 a	12-30	4.54	1.041	0.849	*0.715*	0.030		254	
4:24 a	13-24	4.33	1.086	*.852*	.718	.025			
4:18 a	14-29	3.94	1.133	.900	*.736*	.020			
4:13 a	15-23	3.73	1.161	*.903*	.739	.020			
3:55 a	21-44	2.69	1.262	*.952*	.749	.020			
3:30 a	22-44	2.58	1.277	.955	*.752*	.020			
2:17 a	33-40	1.80	1.401	1.003	*.806*	.020	5		P=50.2.
2:12 a	34-19	1.78	1.398	*1.008*	.809	.020			
0:47 a	43-02	1.46	1.466	*1.034*	.826	.020			
0:43 a	42-14	1.49	1.467	1.034	*.826*	.020			

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, Superintendent United States Naval Observatory. Data furnished by Naval Observatory, in cooperation with Harvard, Perkins, and Mount Wilson Observatories. The differences of longitude are measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column]

Date	Eastern standard civil time	Heliographic Diff. long.	Heliographic Longitude	Heliographic Latitude	Area Spot	Area Group	Total area for each day
1933	h. m.	°	°	°			
Feb. 2 (Naval Observatory)	11 20	−62.0	303.3	+13.0		1173	
		−45.0	320.3	+10.0		46	
		−36.0	329.3	+10.0	77		
		+15.0	20.3	+6.0		216	1,512
Feb. 3 (Naval Observatory)	14 31	−48.0	302.4	+13.0		1111	
		−21.0	329.4	+10.0	77		
		+30.0	20.4	+6.0		185	1,373
Feb. 4 (Mount Wilson)	12 30	−35.0	303.3	+13.0		1091	
		−8.0	330.3	+11.0	80		
		+48.0	26.3	+8.0	114		1,285
Feb. 5 (Naval Observatory)	12 53	−22.0	303.0	+13.0		1173	
		+4.0	329.0	+10.0	77		
		+62.0	27.0	+6.0	123		1,373
Feb. 6 (Naval Observatory)	10 55	−9.0	303.9	+13.0		957	
		+16.0	328.9	+10.0	62		
		+74.0	26.9	+6.0	154		1,173
Feb. 7 (Naval Observatory)	10 20	+2.0	302.0	+13.0		1049	
		+29.0	329.0	+10.0	77		
		+70.0	10.0	−12.0		46	1,172
Feb. 8 (Naval Observatory)	10 43	+16.0	302.6	+13.0		710	
		+43.0	329.6	+9.0	62		772
Feb. 9 (Naval Observatory)	10 32	+29.0	302.6	+13.0		741	
		+56.0	329.6	+9.0	93		834

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard civil time	Heliographic			Area		Total area for each day
		Diff. long.	Longitude	Latitude	Spot	Group	
1933	h. m.	°	°	°			
Feb. 10 (Naval Observatory)	11 18	+41.0	301.0	+13.0		710	
		+69.0	329.0	+9.0	62		772
Feb. 11 (Naval Observatory)	11 0	+56.0	303.0	+13.0		679	679
Feb. 12 (Naval Observatory)	12 14	+70.0	303.1	+13.0		556	556
Feb. 13 (Perkins Observatory)	12 30	+86.0	305.8	+5.0		125	125
Feb. 14 (Mount Wilson)	14 10	−57.0	148.7	+1.0		4	4
Feb. 15 (Mount Wilson)	17 35	−41.0	149.7	+1.0		3	3
Feb. 16 (Naval Observatory)	11 29		No spots.				
Feb. 17 (Mount Wilson)	12 30		No spots.				
Feb. 18 (Naval Observatory)	12 22		No spots.				
Feb. 19 (Naval Observatory)	11 24		No spots.				
Feb. 20 (Perkins Observatory)	12 30		No spots.				
Feb. 21 (Naval Observatory)	10 51		No spots.				
Feb. 22 (Naval Observatory)	11 10		No spots.				
Feb. 23 (Naval Observatory)	11 18		No spots.				
Feb. 24 (Naval Observatory)	11 15		No spots.				
Feb. 25 (Perkins Observatory)	15 35		No spots.				
Feb. 26 (Naval Observatory)	13 4		No spots.				
Feb. 27 (Naval Observatory)	11 40	−63.0	332.9	+7.0	31		31
Feb. 28 (Naval Observatory)	11 29	−72.0	310.8	+16.0	123		123
Mean daily area for February							437

PROVISIONAL SUN-SPOT RELATIVE NUMBERS FOR FEBRUARY, 1933

[Dependent alone on observations at Zurich and its station at Arosa]

[Data furnished through the courtesy of Prof. W. Brunner, University of Zurich, Switzerland]

February 1933	Relative numbers	February 1933	Relative numbers	February 1933	Relative numbers
1	*ad* 45	11		21	0
2		12	16	22	0
3	67	13	11	23	0
4		14	8	24	0
5	*a* 62	15	0	25	0
6	*b* 69	16	0	26	0
7	*b* 80	17	0	27	8
8	53	18	0	28	*d* 14
9	46	19	0		
10	32	20	0		

Mean: 25 days=20.4.

a=Passage of an average-sized group through the central meridian.
b=Passage of a large group or spot through the central meridian.
c=New formation of a center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central zone.
d=Entrance of a large or average-sized center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

[Aerological Division, W. R. Gregg, in charge]

By L. T. SAMUELS

Free-air temperatures during February were considerably below normal at the northern stations with the largest departures occurring at Ellendale. Temperatures at the southern stations averaged above normal with the largest departures at Atlanta. Table 1 shows that, contrary to the usual inverse relationship between the monthly temperature and relative humidity departures, this relationship was direct at most stations. Under such conditions there often is found a correlation between the monthly precipitation and relative humidity departures. Such a relationship was strikingly apparent at those stations having temperature and relative humidity departures of the same sign, e.g., Chicago, −0.92 in.; Atlanta, +0.87 in.; Omaha, −0.64 in.; Cleveland, −0.52 in.; and Dallas, +0.34 in.

As would be expected from the fact that the normal latitudinal temperature gradient was intensified by the super-normal temperatures over the south and subnormal temperatures over the north, the resultant wind velocities for the month were considerably above normal. Resultant free-air wind directions were close to normal over most of the country. The greatest deviations occurred over the north Pacific States where the normal southwesterly component was replaced by one from the northwest.

TABLE 1.—*Free-air temperatures and relative humidities during February 1933*

TEMPERATURE (°C.)

Altitude (meters) m.s.l.	Atlanta, Ga. (303 meters)[1]		Boston, Mass. (6 meters)[2]		Chicago, Ill. (187 meters)[3]		Cleveland, Ohio (246 meters)[3]		Dallas, Tex. (146 meters)[4]		Ellendale, N.Dak. (444 meters)		Omaha, Nebr. (300 meters)[5]		San Diego, Calif. (9 meters)[6]		Washington, D.C. (2 meters)[6]	
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
Surface	5.4	(7)	−0.6		−6.5	(7)	−3.4	(7)	4.2	(7)	−12.1	−2.4	−6.0	(7)	10.1	−2.5	.0	−1.7
500	5.9	(7)	−4.0		−6.2	(7)	−4.1	(7)	5.3	(7)	−12.3	−2.6	−6.1	(7)	10.5	−1.3	.3	−.7
1,000	5.9	0	−5.4		−6.8	−3.0	−6.4	−2.6	5.6	−1.6	−11.5	−2.9	−4.1	−0.7	8.8	−1.4	−.4	+.2
1,500	5.8	+1.8	−7.1		−8.0	−3.2	−7.6	−2.8	5.2	−.7	−12.4	−4.3	−4.4	−1.4				
2,000	4.5	+2.4	−8.9		−9.3	−3.0	−8.8	−2.5	4.7	+.7	−14.1	−4.6	−6.4	−2.1	4.3	−1.1	−2.9	+.6
2,500	2.7	+3.0	−11.0		−11.6	−3.4	−10.8	−2.6	2.3	+.7	−16.9	−5.1	−8.7	−2.2				
3,000	.6	+3.4	−13.3		−14.4	−3.8	−13.4	−2.8	−.1	+.8	−19.3	−4.8	−11.4	−2.3	−.7	−1.3	−6.8	+.8
4,000	−5.4	+3.2	−19.0		−19.3	−2.8	−19.1	−2.6	−5.5	+.3			−17.6	−2.9			−11.2	+2.8
5,000	−12.1	+2.1	−26.3		−25.7	−2.7	−26.2	−3.2	−12.4	−.9			−23.9	−2.4				

RELATIVE HUMIDITY (PERCENT)

Altitude (meters) m.s.l.	Atlanta Mean	Atlanta Departure	Boston Mean	Boston Departure	Chicago Mean	Chicago Departure	Cleveland Mean	Cleveland Departure	Dallas Mean	Dallas Departure	Ellendale Mean	Ellendale Departure	Omaha Mean	Omaha Departure	San Diego Mean	San Diego Departure	Washington Mean	Washington Departure
Surface	83	(7)	68		78	(7)	75	(7)	82	(7)	76	−5	72	(7)	67	−1	71	0
500	82	(7)	66		72	(7)	73	(7)	74	(7)	75	−5	66	(7)	59	−3	62	−1
1,000	80	+20	64		64	−7	70	−1	61	+2	68	−2	54	−10	51	−4	56	−4
1,500	70	+14	61		59	−3	62	0	54	+2	65	+3	49	−8				
2,000	64	+11	59		52	−5	55	−2	47	0	64	+5	45	−8	40	−3	52	−1
2,500	62	+11	57		48	−8	50	−6	46	+2	65	+6	41	−11				
3,000	58	+9	54		47	−10	52	−5	45	+3	60	+2	41	−11	30	−1	52	+2
4,000	54	+8	51		47	−10	50	−7	41	+5			45	−5			54	+3
5,000	49	+3	49		47	−11	55	−3	40	+8			41	−9				

Weather Bureau airplane observations made near 5 a.m.; Navy airplane observations near 7 a.m.; Ellendale kite observations near 9 a.m. (seventy-fifth meridian time).

[1] Temperature and humidity departures based on normals of Due West, S.C.
[2] Airplane observations made by Massachusetts Institute of Technology.
[3] Temperature and humidity departures based on normals of Royal Center, Ind.
[4] Temperature departures based on normals determined by interpolating between those of Groesbeck, Tex., and Broken Arrow, Okla. Humidity departures based on normals of Groesbeck, Tex.
[5] Temperature and humidity departures based on normals of Drexel, Nebr.
[6] Naval air stations.
[7] Surface and 500-meter departures omitted because of difference in time of day between airplane observations and those of kites upon which the normals are based.

TABLE 2.—*Free-air resultant winds (meters per second) based on pilot balloon observations made near 7 a.m. (E.S.T.) during February 1933*

[Wind from N=360°; E=90°, etc.]

Altitude (meters) m.s.l.	Albuquerque, N. Mex. (1,554 meters) Direction	Velocity	Atlanta, Ga. (309 meters) Direction	Velocity	Bismarck, N.Dak. (518 meters) Direction	Velocity	Brownsville, Tex. (12 meters) Direction	Velocity	Burlington, Vt. (132 meters) Direction	Velocity	Cheyenne, Wyo. (1,873 meters) Direction	Velocity
	°		°		°		°		°		°	
Surface	357	1.2	320	1.6	306	2.2	89	0.6	222	1.7	273	5.8
500			325	1.4			123	3.8	252	6.0		
1,000			273	4.9	293	10.5	163	3.0	281	7.0		
1,500			273	8.7	298	12.8	218	3.0	283	9.6		
2,000	310	3.3	284	11.3	292	13.3	238	5.3	305	11.6	272	8.3
2,500	291	5.9	276	9.0	290	13.9	239	4.1	289	12.2	277	13.9
3,000	282	9.1	302	8.6	283	12.4	238	7.6			292	16.2
4,000	274	14.5									285	16.0
5,000	264	14.7										

Altitude (meters) m.s.l.	Chicago, Ill. (192 meters) Direction	Velocity	Cleveland, Ohio (245 meters) Direction	Velocity	Dallas, Tex. (154 meters) Direction	Velocity	Havre, Mont. (762 meters) Direction	Velocity	Jacksonville, Fla. (14 meters) Direction	Velocity	Key West, Fla. (11 meters) Direction	Velocity
	°		°		°		°		°		°	
Surface	276	2.3	245	3.6	257	0.2	242	4.2	343	1.6	93	2.2
500	275	5.7	256	7.2	349	.1			34	.3	114	4.5
1,000	280	9.4	266	11.0	283	3.3	264	7.6	279	2.0	144	4.7
1,500	273	10.3	269	12.5	273	5.9	282	12.0	277	7.3	167	3.2
2,000	279	12.3	271	14.7	283	9.2	298	13.4	274	9.1	203	2.8
2,500	293	14.8	273	16.9	281	13.1	293	13.3	271	10.6	214	3.2
3,000	274	11.8	287	16.4	273	17.0	287	13.2			216	4.8
4,000											265	4.5
5,000												

Altitude (meters) m. s. l.	Los Angeles, Calif. (217 meters) Direction	Velocity	Medford, Oreg. (410 meters) Direction	Velocity	Memphis, Tenn. (83 meters) Direction	Velocity	New Orleans, La. (25 meters) Direction	Velocity	Oakland, Calif. (8 meters) Direction	Velocity	Oklahoma City, Okla. (402 meters) Direction	Velocity
	°		°		°		°		°		°	
Surface	343	1.4	290	0.6	277	0.5	37	1.8	28	1.8	308	0.7
500	19	1.4	330	.6	239	2.3	57	2.4	358	3.6	213	1.0
1,000	29	2.1	231	1.0	251	3.9	291	1.7	350	6.6	260	4.6
1,500	355	2.8	252	3.5	260	6.7	264	3.6	345	6.7	270	6.4
2,000	338	4.1	285	4.5	272	9.4	258	5.8	345	7.4	275	8.8
2,500	330	6.4	322	7.9	276	12.0			340	9.0	273	10.2
3,000	337	6.7	330	10.4	283	13.8			335	9.1	275	13.0
4,000	338	5.7	333	13.1					319	9.7	270	15.9
5,000												

Altitude (meters) m. s. l.	Omaha, Nebr. (306 meters) Direction	Velocity	Phoenix, Ariz. (356 meters) Direction	Velocity	Salt Lake City, Utah (1,294 meters) Direction	Velocity	Sault Ste. Marie, Mich. (198 meters) Direction	Velocity	Seattle, Wash. (14 meters) Direction	Velocity	Washington, D.C. (10 meters) Direction	Velocity
	°		°		°		°		°		°	
Surface	233	0.7	89	0.3	178	1.9	285	1.0	148	2.0	275	1.9
500	241	2.9	45	1.0			275	3.3	215	3.9	274	7.2
1,000	272	7.0	38	1.8			282	6.0	269	3.3	290	9.9
1,500	278	9.5	241	.5	189	3.7	273	7.2	295	3.5	294	12.1
2,000	281	10.8	264	2.4	224	3.2	288	9.9	302	5.3	288	14.3
2,500	283	12.7	270	3.9	273	4.8	273	11.8	327	6.6	286	14.3
3,000	282	13.3	270	5.5	284	6.8			329	10.6	282	14.2
4,000	278	13.2	282	10.0	294	7.7						
5,000			282	7.1								

RIVERS AND FLOODS

By MONTROSE W. HAYES

[In charge River and Flood Division]

In February 1933 floods occurred in Michigan, the South Atlantic, Gulf, and Ohio Valley States, and in Oregon and Idaho. Several of those in the South Atlantic and Gulf States were still in progress at the close of the month. With the exception of the one in the Tallahatchie River, in Mississippi, which will be discussed in a later issue of the MONTHLY WEATHER REVIEW, none was of much importance. In all instances the damage was slight.

The floods in the Grand River in Michigan were caused by ice gorges.

Table of flood stages in February 1933

[All dates in February unless otherwise specified]

River and station	Flood stage	Above flood stages—dates From—	To—	Crest Stage	Date
ST. LAWRENCE DRAINAGE					
	Feet			*Feet*	
Grand: Portland, Mich	12	26	26	12.0	26.
ATLANTIC SLOPE DRAINAGE					
Roanoke: Williamston, N.C	10	15	28	10.5	19–27.
Peedee:					
Mars Bluff Bridge, S.C	17	13	26	18.6	24.
Poston, S.C	18	18	28	18.4	23–26.
Black: Kingstree, S.C	10	12	Mar. 1	11.2	19, 20.
Santee:					
Rimini, S.C	12	Jan. 26	5	13.7	Jan. 29.
		9	(1)	15.2	24.
Ferguson, S.C	12	Jan. 26	7	13.3	Jan. 31.
		9	(1)	13.7	24–27.
Savannah: Ellenton, S.C	14	Jan. 26	6	17.5	Jan. 29.
		9	(1)	19.5	23.

[1] Continued into March.

Table of flood stages in February 1933—Continued

River and station	Flood stage	Above flood stages—dates From—	To—	Crest Stage	Date
ATLANTIC SLOPE DRAINAGE—contd.					
Ogeechee:	*Feet*			*Feet*	
Dover, Ga	7	8	(1)	8.1	22–24.
Meldrim, Ga	9	9	(1)	10.6	26–28.
Ocmulgee: Abbeville, Ga	11	16	19	11.3	18.
		23	(1)	13.4	27.
Altamaha:					
Charlotte, Ga	12	Jan. 28	(1)	16.5	28.
Everett City, Ga	10	11	(1)	10.8	21–25.
EAST GULF OF MEXICO DRAINAGE					
Apalachicola: Blountstown, Fla	15	Jan. 28	(1)	20.4	25.
Cahaba: Centerville, Ala	23	8	8	23.7	8.
		20	20	25.0	20.
Alabama:					
Selma, Ala	35	22	26	38.2	24.
Millers Ferry, Ala	35	21	(1)	42.4	25, 26.
Tombigbee:					
Aberdeen, Miss	34	9	10	34.5	10.
Lock No. 4, Demopolis, Ala	39	10	Mar. 3	49.5	22.
Lock No. 3, Ala	33	9	Mar. 5	52.4	22.
Lock No. 2, Ala	46	12	Mar. 3	54.4	23.
Lock No. 1, Ala	31	11	Mar. 9	37.0	25, 26.
Pearl: Jackson, Miss	20	8	(1)	25.0	16, 17.
West Pearl: Pearl River, La	13	1	7	14.1	2.
		14	(1)	15.2	28.
MISSISSIPPI SYSTEM					
Upper Mississippi Basin					
Illinois: Peru, Ill	14	Jan. 22	5	14.8	4.
		8	20	15.4	8.
		23	Mar. 5	16.5	24.
Ohio Basin					
Barren: Bowling Green, Ky	20	21	23		

Table of flood stages in February 1933—Continued

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
MISSISSIPPI SYSTEM—continued					
Ohio Basin—Continued					
Green:	*Feet*			*Feet*	
Munfordville, Ky	28	21	23	29.4	22.
Lock No. 6, Brownsville, Ky	28	22	23	28.1	22, 23.
Lock No. 4, Woodbury, Ky	33	17	26	39.4	23.
Lock No. 2, Rumsey, Ky	34	23	(1)	36.7	27.
West Fork of White: Edwardsport, Ind.	12	27	28	13.6	28.
White: Decker, Ind	18	Jan. 24	4	21.8	Jan. 28, 29.
Wabash: Mt. Carmel, Ill	16	Jan. 23	2	20.9	Jan. 28, 29.
Cumberland:					
Carthage, Tenn	40	22	22	40.8	22.
Nashville, Tenn	40	20	26	45.0	21.
Clarksville, Tenn	46	21	27	50.6	22.
Lock F, Eddyville, Ky	50	21	Mar. 3	58.0	27.
North Fork of Holston: Mendota, Va.	8	15	15	8.0	15.
Pigeon: Newport, Tenn	6	8	9	7.1	8.
		15	16	10.3	15.
French Broad: Dandridge, Tenn	12	15	16	13.9	15.
Elk: Fayetteville, Tenn	14	14	18	23.5	14.
		20	21	17.6	20.
Tennessee:					
Rockwood, Tenn	20	16	17	21.6	16.
Chattanooga, Tenn	30	17	18	32.6	17.
Bridgeport, Ala	18	16	23	23.0	18.
Guntersville, Ala	25	17	25	31.1	20.
Florence, Ala	18	18	24	21.1	21.
Riverton, Ala	33	15	27	41.9	22.
Savannah, Tenn	32	16	27	41.7	23.
Johnsonville, Tenn	31	20	28	34.3	24.

[1] Continued into March.

Table of flood stages in February 1933—Continued

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
MISSISSIPPI SYSTEM—continued					
Ohio Basin—Continued					
Ohio:	*Feet*			*Feet*	
Dam No. 50, Fords Ferry, Ky	32	25	Mar. 2	33.6	27.
Dam No. 52, Brookport, Ill	35	22	Mar. 4	39.2	28.
Dam No. 53, Grand Chain, Ill	38	23	Mar. 4	42.0	Mar. 1.
White Basin					
White: Georgetown, Ark	21	Jan. 25	4	22.1	Jan. 30.
Arkansas Basin					
Arkansas: Yancopin, Ark	29	5	13	29.7	10–11.
Red Basin					
Sulphur: Ringo Crossing, Tex	20	28	(1)	23.8	28.
Lower Mississippi Basin					
St. Francis: St. Francis, Ark	18	Jan. 23	3	22.3	Jan. 28.
Tallahatchie: Swan Lake, Miss	24	Dec. 16	(1)	33.0	26.
Yazoo: Yazoo City, Miss	25	8	(1)	25.8	28.
Atchafalaya Basin					
Atchafalaya: Atchafalaya, La	22	Jan. 10	(1)	22.9	11–19.
PACIFIC SLOPE DRAINAGE					
Columbia Basin					
Long Tom: Monroe, Oreg	10	Jan. 26	2	13.6	Jan. 28.
Snake: Weiser, Idaho	14	16	18	15.0	17.

WEATHER OF THE ATLANTIC AND PACIFIC OCEANS

[The Marine Division, W. F. McDonald in charge]

NORTH ATLANTIC OCEAN

By W. F. McDONALD

Atmospheric pressure.—There was a decided change in the average pressure situation over the North Atlantic in February 1933, as compared with the preceding month. Instead of a deeply depressed barometer over Iceland the average pressure at Reykjavik was almost half an inch above the February normal. At the same time the pressure over middle latitudes decreased, and the barometer at Horta averaged two tenths of an inch below normal. Pressures along the American coast were normal to a tenth of an inch below. (See table 1.)

Lowest pressures reported from ships at sea were, 28.59 inches, from the French S.S. *Paris*, near latitude 44° N., longitude 54° W., on the evening of February 5; and 28.56 inches (the lowest reported from any part of the Atlantic or adjacent land areas during the month) from the British S.S. *Majestic*, near latitude 42° N., longitude 57° W., on the morning of the 27th.

The highest readings reported from ships on the North Atlantic were 30.68 inches, from the American ships *Wytheville* and *Leviathan*, between 40° and 45° N., and 45° and 65° W., on the evening of the 10th and morning of the 11th.

Cyclones and gales.—Storminess diminished greatly in intensity over the North Atlantic in February. The alteration in average pressures, outlined above, reflects the lessening of the barometric gradient between the normal Atlantic HIGH, and the Icelandic LOW, that accompanied this reduction in gale intensities over the main trans-Atlantic routes. While winds of gale force occurred in some part of the ocean on nearly every day in the month, the force seldom exceeded Beaufort 9, and on only a few days were gales reported over wide areas.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, February 1933*

Station	Average pressure	Departure	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Julianehaab, Greenland	30.03	--------	30.79	27	29.14	13
Reykjavik, Iceland	29.98	+0.44	30.58	18	28.74	1
Lerwick, Shetland Islands	29.79	+.07	30.46	11	28.55	2
Valencia, Ireland	29.96	+.06	30.69	12	29.06	25
Lisbon, Portugal	30.10	.00	30.44	7	29.52	26
Madeira	30.02	−.05	30.37	7	29.62	24
Horta, Azores	29.95	−.20	30.48	10	29.52	25
Belle Isle, Newfoundland	29.77	+.02	30.58	11	28.82	16
Halifax, Nova Scotia	29.81	−.10	30.52	11	28.80	28
Nantucket	29.93	−.11	30.67	10	29.18	26
Hatteras	30.10	−.01	30.70	10	29.51	4
Bermuda	30.07	−.05	30.48	14	29.46	27
Turks Island	30.10	+.02	30.20	14	29.90	27
Key West	30.10	+.03	30.30	9	29.77	28
New Orleans	30.13	+.04	30.66	9	29.70	7
Cape Gracias, Nicaragua	29.95	−.04	30.04	15	29.84	27

NOTE.—All data based on a.m. observations only with departures compiled from best available normals related to time of observation, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

Three ships experienced winds of force 12, as follows: the American S.S. *Montoso*, southwest of Bermuda, on the 4th; the Norwegian S.S. *Taurus*, about 600 miles south of Sable Island, on the 6th, and the American S.S. *West Quechee*, in a similar location, on the 27th. Whole gale to storm winds were encountered by a number of other vessels (as shown by the accompanying table) mostly between the 4th and 7th, the 16th to 18th, and on the 27th, which were the stormiest periods of the month on the main sailing routes.

Cyclonic storms of considerable intensity dominated the middle and northern areas of the North Atlantic during the first week, but the Atlantic HIGH was fully established by the 8th, and continued dominant until the middle of the month. The culmination of the cyclonic

movements and beginning of reestablishment of the high pressure belt are shown on chart VIII, for February 7.

On the 14th (see ch. IX), the usual Icelandic LOW was entirely displaced by a belt of high pressure that extended from the Pacific across North America and thence northeastward to the British Isles and Iceland. This was the maximum development of high pressure over the Atlantic. Shortly thereafter, this condition was broken up by the development of a succession of disturbances originating south of the Azores, that by joining with similar developments moving into the Atlantic over the Grand Banks, repeatedly disrupted the Atlantic HIGH during the latter half of the month. The gradual increase in extent and depth of these pulsations of low pressure resulted finally in domination of the North Atlantic by a belt of low pressure that at the close of the month, extended entirely across the ocean between the thirtieth and fifty-fifth parallels of latitude. At the same time, the normal LOW of higher latitudes was replaced by a HIGH that covered the whole polar region and extended down over Greenland and Iceland.

Mexican Gulf "northers" and the Caribbean trade winds.—On February 8, an intense HIGH moved down over the Gulf of Mexico, preceded by a sharp depression. Southerly winds of force 7 attending the cyclonic trough were quickly over-mastered by the following northerly gale, and northerly winds of force 7 to 8 prevailed on the 8th and morning of the 9th, as far southward as the Florida Straits and Yucatan Channel.

The northeast trade in the Caribbean region was intensified to moderate gale force at times over the western part of that sea, especially between Aruba and Panama. The trades diminished considerably in intensity after the 20th.

Fog.—Fog increased slightly in the region between New York and the Grand Banks, where this condition was reported on 4 to 7 days, but no fog was reported from midocean, and in only a few scattered cases over the area between the Azores and the European coast. The northern Gulf of Mexico again experienced an unusual number of fogs, 11 days with fog being reported off Galveston and along the Louisiana coast.

OCEAN GALES AND STORMS, FEBRUARY 1933

Vessel	Voyage		Position at time of lowest barometer		Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° ′	° ′				Inches					
Atlantian, Br.S.S.	Liverpool	Boston	50 18 N	36 13 W	Feb. 2	8 p., Feb 2	Feb. 2	29.08	NE	NNE, 8	NNE	NNE, 8	Steady.
Ampetco, Belg.S.S.	Rouen	Baytown	30 00 N	45 50 W	Jan. 30	4 a., 2	do	29.54	SW	NW, 8	NW	NW, 8	do
Montoso, Am.S.S.	Puerto Rico	New York	30 35 N	72 00 W	Feb. 4	8 p., 4	Feb. 6	29.69	WSW	WSW, 7	N	NW, 12	
San Tirso, Br.S.S.	Liverpool	Mexico	42 50 N	28 20 W	Jan. 31	2 a., 4	Feb. 9	29.31	SW	SW, 6	NNW	—, 11	SSW-SW.
Topa Topa, Am.S.S.	Tampa	Havre	39 00 N	35 49 W	Feb. 3	5 a., 5	Feb. 8	28.91	NW	S, 10	N	S, 10	NW-S.
Independence Hall Am. S.S.	Bordeaux	New York	43 23 N	55 08 W	Feb. 5	4 p., 5	Feb. 10	28.51	W	SW, 9	WNW	W, 11	E-S-W.
Tachira, Am.S.S.	New York	La Guayra	28 02 N	69 18 W	do	10 p., 5	Feb. 6	29.95	NW	—, 8	N	NW, 8	NW-N.
Afoundria, Am.S.S.	Glasgow	Pensacola	48 22 N	16 47 W	Feb. 6	Noon, 6	Feb. 8	29.48	WSW	SW, 7	SSW	SW, 10	
Taurus, Nor.S.S.	Savannah	London	37 56 N	58 10 W	Feb. 4	do	do		S	NW, 11	WNW	WNW, 12	S-W-WNW.
Georgia, Dan.S.S.	Antwerp	Norfolk	41 38 N	38 35 W	Feb. 5	1 p., 7	do	29.17	SW	SW, 10	N	SW, 10	SW-NW-N.
Otho, Am.S.S.	New York	Nigeria	5 43 N	0 38 E	Feb. 7	1 a., 7	Feb. 7	29.84	SW		NW	N, 8	
Fred W. Weller, Am.S.S.	Corpus Christi.	Boston	26 20 N	90 55 W	Feb. 8	7 a., 8	Feb. 9	30.03	N	N, 7	NE	NNW, 8	
Steel Trader, Am.S.S.	Swansea	St. John, N.B.	52 02 N	17 18 W	do	3 a., 9	Feb. 10	29.61	SW	SW, 8	WNW	SSW, 9	SSW-WSW.
West Imboden, Am.S.S.	Jacksonville	Maceio	22 21 N	66 03 W	Feb. 10	Noon, 10	Feb. 15	30.14	NE	NE, 7	NE	—, 8	Steady.
Samaria, Br.S.S.	Halifax	Plymouth	Halifax		Feb. 11	10 p., 11	Feb. 13	29.25	SSE	SW, —	WNW	ESE, 9	ESE-WSW.
Daytonian, Br.S.S.	New York	Liverpool	46 20 N	42 55 W	Feb. 12	Mdt., 12	do	29.57	SSE	SSE, —	NW	—, 9	SSE-S-W.
United States, Dan.S.S.	Oslo	New York	59 22 N	1 50 W	do	11 p., 12	Feb. 14	30.08	W	W, 7	NW	W, 9	W-NW.
Gonzenheim, Ger.S.S.	Galveston	Bremen	40 19 N	58 47 W	Feb. 11	4 a., 12	Feb. 12	29.73	SE	SSW, 7	NW	S, 11	SW-WNW.
City of Dalhart, Am.M.S.	Port Said	New York	35 50 N	42 15 W	Feb. 13	10 p., 13	Feb. 15	29.94	NNW	NNW, 8	N	N, 10	SSW-NNW.
Malayan Prince, Br.M.S.	Gibraltar	Halifax	40 50 N	40 00 W	do	8 a., 16	Feb. 16	29.26	SW	SSW, 10	NW	SSW, 10	SSW-NW.
Steel Trader, Am.S.S.	Swansea	St. John	45 29 N	58 12 W	Feb. 16	1 a., 16	do	29.07	W	W, 2	W	W, 10	Steady.
Caledonia, Br.S.S.	Belfast	New York	47 20 N	47 15 W	do	Noon, 16	Feb. 17	28.98	SE	SE, 9	W	SSE, 10	SE-S-W.
Steelmaker, Am.S.S.	Canal Zone	London	35 15 N	48 02 W	do	8 p., 16	Feb. 18	29.75	SW	SW, 6	NNE	N, 9	SW-NW.
Duquesne, Am.S.S.	Houston	Havre	34 32 N	43 07 W	Feb. 17	6 a., 17	Feb. 19	29.82	N	N, 7	NNE	N, 10	N-NNW-N.
Delilian, Br.S.S.	Montserrat	do	34 10 N	38 55 W	do	10 p., 18	do	29.44	NW	N, 10	NE	N, 10	N-NE.
West Hika, Am.S.S.	Tampa	do	41 30 N	55 40 W	Feb. 21	8 p., 21	Feb. 21	29.56	SE	S, 10	NW	—, 10	S-NW.
Alberta, Ital.S.S.	Savannah	Malta	39 57 N	27 15 W	Feb. 22	Mdt., 22	Feb. 23	29.88	SSE	S, 8	SSE	ESE, 8	
Sarcoxie, Am.S.S.	Havre	New York	44 00 N	36 54 W	Feb. 24	2 a., 24	Feb. 24	29.68	N	N, 9	NE	N, 9	N-NE.
West Isleta, Am.S.S.	Cape Town	Boston	38 00 N	68 30 W	Feb. 25	—, 26	Feb. 28	29.93	SW	NW, 10	NW	NW, 10	NW-NNW-NW.
Lara, Am.S.S.	Maracaibo	New York	30 40 N	70 47 W	Feb. 26	2 p., 26	do	29.63	WSW	NW, 8	NNW	NW, 9	WSW-NW.
West Madaket, Am.S.S.	Manchester	Pensacola	29 10 N	58 45 W	do	4 a., 27	do	29.47	SW	SSW, 8	W	SW, 9	SSW-NNW.
Conte di Savoia, Ital.S.S.	New York	Gibraltar	40 00 N	48 33 W	do	—, 27	Feb. 27	28.86	E	SW, —	SW	SW, 9	
City of Omaha, Am.S.S.	Bordeaux	Galveston	28 40 N	54 00 W	Feb. 27	4 p., 27	Feb. 28	29.57	SSW	SSW, 10	WNW	SSW, 10	SSW-WSW.
Capulin, Am.S.S.	Scotland	Boston	58 27 N	19 50 W	Feb. 24	—, 27	do	29.56	E	NE, 9	ENE	—, 10	NE-NNE.
West Quechee, Am.S.S.	Hatteras	Bishop Rock	40 00 N	62 30 W	Feb. 25	2 a., 27	Feb. 27	28.61	SSE	NW, 9	W	NW, 12	
NORTH PACIFIC OCEAN													
Makawao, Am.S.S.	Kauai, T.H.	San Francisco.	32 20 N	150 20 W	Feb. 3	4a., 3	Feb. 3	30.03	SE	SE, 7	SE	SE, 8	Steady.
Niagara, Br.S.S.	Victoria	Honolulu	33 58 N	146 50 W	do	2p., 5	Feb. 5	29.24	SSE	S, 8	SW	SE, 9	SE-S-SW.
Alynbank, Br.M.S.	San Pedro	Yokohama	32 22 N	162 27 E	Feb. 4	8p., 4	Feb. 4	29.54	SW	S, —	W	S, 9	S-WSW-NW.
Kiyo Maru, Jap.S.S.	Estero Bay	do	30 54 N	160 24 W	do	4a., 4	do	29.35	WNW	W, —	WNW	NW, 9	WNW-NW.
Do	do	do	31 26 N	168 00 W	Feb. 6	2p., 6	Feb. 9	29.39	SW	W, —	W	W, 9	SW-W-WNW.
Skramstad, Nor. M.S.	Cebu, P.I.	San Pedro	35 42 N	170 30 W	do	7p., 6	Feb. 7	28.62	W	W, —	WSW	W, 10	S-SW-W.
Silverwillow, Br. M.S.	Manila	Portland	43 30 N	172 00 W	Feb. 8	10p., 8	Feb. 9	29.21	WNW	WNW, 9	W	WNW, 9	WNW-NW.
S. C. T. Dodd, Am. S.S.	Balboa	Martinez	13 30 N	93 25 W	Feb. 9	4a., 9	do	29.90	NW	NNW, 7	NNE	N, 8	NW-NNW-N.
Koyo Maru, Jap.S.S.	Port San Luis.	Yokohama	32 51 N	155 16 W	Feb. 8	11p., 8	Feb. 10	29.89	W	W, 8	SW	W, 9	Steady.
Mobile City, Am.S.S.	Hilo	Panama Canal.	12 25 N	110 07 W	Feb. 13	2p., 13	Feb. 13	29.82	ENE	E, 8	E	E, 8	ENE-E.
Juyo Maru, Jap.S.S.	Miike	Vancouver	47 23 N	171 00 E	Feb. 15	4p., 16	Feb. 18	28.79	N	N, —	W	NE, 9	
Do	do	do	50 06 N	138 40 W	Feb. 23	6p., 23	Feb. 23	29.61	S	SSW, —	SW	S, 9	
Monterey, Am.S.S.	Pago Pago	San Pedro	8 43 N	162 39 W	Feb. 21	2p., 21	Feb. 22	29.83	NE	ENE, —	E	ENE, 8	NE-E.
Koyo Maru, Jap.S.S.	Port San Luis.	Yobohama	34 17 N	140 52 E	Feb. 24	5p., 24	Feb. 25	29.45	S	SW, 8	NW	SSW, 8	SSW-SW.
Ferndale, Nor.M.S.	Grays Harbor	Osaka	33 02 N	152 23 E	Feb. 25	2p., 25	do	29.69	S	SSW, 9	SW	SSW, 10	S-SSW-SW.
Grays Harbor, Am.S.S.	Cebu	Los Angeles	[1] 41 48 N	168 50 W	Feb. 24	—, 27	Feb. 28	30.23	E	E, 9	E	E, 9	Steady.
Golden Sun, Am.S.S.	Darien	San Francisco	45 56 N	146 32 W	Feb. 27	Noon, 28	do	29.73	NNW	NW, 8	NNW	NW, 8	

[1] Position approximate.

NORTH PACIFIC OCEAN, FEBRUARY 1933

By WILLIS E. HURD

Atmospheric pr[illegible]ure was one to nearly two tenths of an inch above the normal along most of the American coast from northern Alaska and the Aleutian Islands to central California. The Aleutian cyclone, which on the average stretched from the Gulf of Alaska far southwestward, was shallower than normal for February. The Pacific anticyclone, central off the California coast, was abnormally well developed locally for the month, but less extensive than usual.

The Asiatic anticyclone lacked the oceanward extent and development that characterized it in January. Pressure from Guam to the South China Sea was low, averaging 0.11 inch below normal at Manila.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean, February 1933, at selected stations*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Point Barrow	30.26	+0.14	30.94	28	29.82	24
Dutch Harbor	29.76	+.16	30.90	27	28.84	2
St. Paul	29.81	+.16	30.90	26, 27	29.10	2, 9
Kodiak	29.79	+.17	30.34	5	28.86	24
Juneau	29.93	+.01	30.67	5	28.87	22
Tatoosh Island	30.12	+.12	30.61	9	29.56	28
San Francisco	30.21	+.11	30.44	19	29.95	6
Mazatlan	29.94	−.06	30.02	7	29.84	27
Honolulu	29.99	−.06	30.16	20	29.75	3
Midway Island	30.00	+.01	30.24	20	29.54	6
Guam	29.86	−.05	29.90	1, 10	29.78	28
Manila	29.86	−.11	29.96	5	29.78	10
Naha	30.01	−.04	30.18	18	29.72	28
Chichishima	30.01	+.03	30.22	5	29.66	28
Nemuro	29.89	-------	30.34	4, 5	29.34	24

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observation.

Cyclones and gales.—February, as a whole, was far less stormy than January, and subject to fewer wind velocities exceeding force 9 than any preceding month since August 1932. Only two gales of force 10 have been reported for the entire North Pacific for February 1933. One was experienced by the Dutch motorship *Skramstad* on the 6th, at latitude 35°42′ N., longitude 170°30′ W., pressure 28.62 inches. At that time all the mid-Pacific was under the influence of cyclonic conditions, and had been since the 3d, with fresh to strong gales (forces 8–9) along portions of the central and southern steamship routes from longitude 140° W., latitude 37° N., southward nearly to the Hawaiian Islands and westward beyond Midway Island. During the 8th to 10th the gale field spread northward toward the Aleutians, with scattered high winds, few of which were in excess of force 8. The other whole gale (force 10) of the month was experienced by the Norwegian motorship *Ferndale* near 33° N., 152° E.

From the 23d to 25th a deep cyclone lay over the northeastern Pacific, and during its continuance rather widespread gales of force 9 occurred over the northern steamer tracks between 135° W. and the eastern Aleutians.

The American steamer *Grays Harbor* reported a persistent gale from the 25th to 28th near latitude 42° N., longitude 168°–169° W. "Wind," said the observer, Mr. Frank Mechan, third officer, "blew a steady strong gale throughout the 25th, 26th, and 27th, with the wind steady east, force 9, as a consequence of which ship was under reduced speed throughout the 26th and 27th." The weather was strongly anticyclonic, and for the entire period the ship's lowest corrected pressure was 30.23 inches.

No gales were reported near the coast of the United States, and fewer than the normal number occurred over the approaches to Japan.

In low latitudes easterly gales of force 8 were reported south of the Revillagigedo Islands on the 13th, and north of Palmyra Island on the 21st, the latter being an intensification of the trades.

Northers.—A Tehuantepecer of force 7 occurred on the 22d and one of force 8 on the 9th and 10th. The American steamer *Santa Elisa*, in the Gulf of Tehuantepec, reported a "full northerly gale, with heavy clouds over the mountains to the northeast", on the 11th.

Fog.—Fog was reported as occurring off the coast between Tatoosh Island and San Diego on only 4 days. A few scattered fogs were observed over the considerable area traversed in the eastern part of the ocean by steamers on the northern and middle routes.

CLIMATOLOGICAL TABLES[1]

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, February 1933

(For description of tables and charts, see Review, January, p. 26)

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	° F.	° F.		° F.			° F.		In.	In.		In.		In.
Alabama	49.1	+0.3	Evergreen	84	25	Riverton	−2	9	6.21	+0.93	Clayton	9.81	Maple Grove	3.80
Arizona	40.4	−7.2	Parker	89	23	Fort Defiance	−26	7	.67	−.66	Rucker Canyon	3.29	5 stations	.00
Arkansas	41.5	−2.1	Crossett	82	24	2 stations	−13	[1] 8	3.53	+.16	Yancopin	8.69	2 stations	1.53
California	42.3	−5.3	El Centro	82	24	do	−23	[1] 7	.83	−3.35	Crescent City	7.16	27 stations	.00
Colorado	20.4	−6.6	Deaton's Ranch	76	24	Westcliffe	−54	10	.48	−.49	Cumbres	3.43	2 stations	.00
Florida	64.6	+4.0	Moore Haven	89	[1] 18	2 stations	14	9	3.24	+.17	Monticello	7.60	Fort Lauderdale	.05
Georgia	50.5	+1.7	Waycross	84	14	Blairsville	0	9	5.87	+.95	Waycross	9.16	Fitzgerald	3.86
Idaho	16.6	−11.1	Kooskia	58	25	Tetonia	−57	8	1.77	+.07	Roland	8.89	Arco	T
Illinois	29.1	−.2	Sparta	74	23	4 stations	−26	9	1.47	−.71	Brookport	4.44	Moline	.17
Indiana	31.4	+.9	Shoals	75	24	5 stations	−20	9	1.88	−.59	Rome	4.31	Fowler	.65
Iowa	22.3	−.1	Clarinda	69	23	Inwood (near)	−31	8	.32	−.77	Inwood (near)	.93	Guthrie Center	.03
Kansas	31.4	−1.6	2 stations	78	24	Oberlin	−28	8	.26	−.76	Pleasanton	1.43	4 stations	T
Kentucky	37.5	+.5	3 stations	75	24	Mount Sterling	−9	9	4.25	+.78	Quicksand	7.27	Cold Spring	1.71
Louisiana	54.6	+.8	Schriever	88	25	Plain Dealing	6	8	6.33	+1.73	Elizabeth	9.04	Jonesville	3.61
Maryland-Delaware	36.2	+2.2	La Plata, Md	70	24	Chewsville, Md	−8	12	3.01	−.07	Crisfield, Md	5.38	Clear Spring, Md	1.54
Michigan	21.3	+1.3	Hastings	60	1	2 stations	−35	9	1.88	+.20	Deer Park	4.83	Hart	.80
Minnesota	8.8	−3.8	2 stations	57	[1] 23	Warroad	−55	8	.67	−.08	Fosston	2.99	Crookston	.02
Mississippi	49.3	−.2	Columbia	84	25	Holly Springs	0	9	6.50	+1.66	Booneville	10.09	State College	3.81
Missouri	32.2	−.8	2 stations	78	23	Macon	−22	[1] 8	1.35	−.68	Sikeston	4.05	Oregon	.21
Montana	16.2	−6.3	Big Timber	63	26	3 stations	−52	9	.67	−.03	Heron	5.17	Mildred	.02
Nebraska	24.1	−1.5	McCook	83	23	2 stations	−37	8	.22	−.50	Atkinson	1.13	2 stations	.00
Nevada	22.5	−11.2	Clay City	77	23	Elko	−37	10	.40	−.62	Arthur	2.05	4 stations	.00
New England	27.4	+4.7	Providence, R. I	68	8	Van Buren, Me	−20	7	3.22	+.05	Portland, Me	6.05	Jackman, Me	1.40
New Jersey	33.5	+3.9	3 stations	67	8	2 stations	−12	13	3.33	−.21	Atlantic City	4.72	Sussex	2.20
New Mexico	30.9	−6.4	Richland (near)	83	20	Dulce	−48	8	.60	−.11	Cloudcroft	2.69	Stanley (near)	.00
New York	27.1	+4.5	Wappingers Falls	68	23	2 stations	−23	6	2.34	−.38	Bridgehampton	4.05	Letchworth Park	.55
North Carolina	43.8	+1.0	Morganton	79	9	Mount Mitchell	−17	9	4.28	+.20	Southport	9.12	Mount Holly	1.75
North Dakota	7.9	−2.3	Fort Yates	58	25	Marmarth	−45	7	.28	−.21	Sanish	1.00	2 stations	T
Ohio	31.9	+2.5	2 stations	69	24	Montpelier	−17	9	1.81	−.81	Wilmington	3.86	Lima	.63
Oklahoma	39.3	−1.6	Tishomingo	85	23	2 stations	−17	[1] 8	1.29	−.07	Antlers	3.60	Fairview	.04
Oregon	28.3	−6.9	Powers	68	[1] 4	2 stations	−54	[1] 9	3.06	−.08	Headworks	15.03	Paisley	.15
Pennsylvania	31.3	+3.2	2 stations	68	24	Muncy Valley	−15	12	2.30	−.67	Snow Hill	4.31	Wellsboro	.73
South Carolina	48.0	+.4	do	82	25	Caesar's Head	0	[1] 9	4.86	+.58	Ferguson	7.20	Darlington	2.22
South Dakota	17.0	−1.6	Vale	66	26	4 stations	−38	[1] 7	.32	−.26	Hardy Ranger Station.	1.32	2 stations	.00
Tennessee	40.7	−.5	Clarksville	79	24	Crossville	−13	9	6.21	+1.74	Moscow	8.90	Tiptonville	2.57
Texas	48.4	−2.6	Mission	93	25	Seminole	−23	8	2.16	+.37	Bon Wier	8.81	3 stations	.00
Utah	18.0	−11.7	St. George	69	28	Woodruff	−44	10	.64	−.59	Silver Lake	4.44	do	.00
Virginia	39.3	+2.2	Diamond Springs	77	25	Burkes Garden	−7	9	3.03	−.08	Pennington Gap	6.80	Woodstock	1.35
Washington	27.2	−6.7	Lowden	62	25	Deer Park	−40	9	3.41	−.44	Wynoochee Oxbow	17.22	2 stations	.12
West Virginia	34.5	+1.1	Robertsburg	77	25	Benson	−12	12	3.13	−.04	Pickens	7.87	Romney	.96
Wisconsin	14.7	−2.4	Beloit	64	23	Grantsburg	−42	8	1.10	−.09	Mellen	2.67	3 stations	.29
Wyoming	14.4	−7.7	Yoder	64	[1] 23	Riverside	−66	9	.63	−.14	Bechler River	5.21	Yoder	T
Alaska (January)	−4.0	−10.1	Dutch Harbor	55	18	Tanana	−68	28	2.00	−.47	View Cove	17.48	Barrow	T
Hawaii	69.4	+.6	Mahukona	91	[1] 16	Kanalohuluhulu	42	[1] 1	7.38	+1.19	Papaikou (Mauka)	25.93	Honokaa	.96
Puerto Rico	73.0	−.9	Juana Diaz	94	9	Guineo Reservoir	42	27	1.21	−1.71	Rio Blanco	4.73	Coamo	.00

[1] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, February 1933*

[Compiled by Annie E. Small]

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature: Departure from normal	Temperature: Maximum	Temperature: Date	Temperature: Mean maximum	Temperature: Minimum	Temperature: Date	Temperature: Mean minimum	Temperature: Greatest daily range	Mean wet thermometer	Mean temperature of the dewpoint	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
New England							30.1	+4.7										73	3.63	+0.4										5.8		
Eastport	76	67	85	29.77	29.86	−0.12	28.4	+6.9	49	9	36	4	6	21	44	26	23	82	2.72	−0.6	10	8,884	nw.	40	sw.	9	7	7	14	6.2	5.6	T
Greenville, Maine	1,070	6		28.66	29.87		19.5		44	8	29	−11	6	10	43				2.28		11	5,415	se.	32		27	8	7	13		32.2	
Portland, Maine	103	82	117	29.78	29.91	−.11	29.0	+5.2	50	23	36	5	10	22	30	25	20	70	6.05	+2.0	12	6,931	nw.	41	nw.	27	12	9	7	4.4	20.9	3.6
Concord	289	70	79	29.60	29.93	−.11	27.6	+4.8	62	8	37	−7	13	18	47				3.37	+.5	8	4,925	nw.	28	w.	21	11	9	8	4.8	21.2	7.5
Burlington	403	11	48	29.48	29.94	−.09	23.9	+4.5	48	8	31	−7	9	16	45				1.67	+.1	12	7,461	s.	37	s.	13	3	8	17	7.7	21.9	8.5
Northfield	876	12	60		29.94	−.10	23.0	+6.6	52	8	32	−7	9	14	46			82	2.16	−.1	14	6,377	s.	25	sw.	9	1	12	15	7.4	20.9	5.0
Boston	125	106	165	29.80	29.94	−.10	33.7	+4.9	66	8	42	9	6	26	37	29	22	63	3.77	+.4	13	6,749	nw.	30	nw.	27	11	10	7	5.0	20.6	4.9
Nantucket	12	14	90	29.92	29.93	−.11	35.0	+4.3	52	20	41	13	6	29	24	31	28	78	4.72	+1.4	14	10,896	w.	39	sw.	8	7	10	11	6.0	8.6	T
Block Island	26	11	46	29.92	29.96	−.10	33.6	+3.2	51	8	40	13	10	28	21	32	28	78	4.24	+.6	13	13,210	w.	58	w.	21	10	8	10	5.8	10.5	T
Providence	160	215	251	29.77	29.95	−.10	32.5	+3.5	60	8	40	9	10	25	35	29	21	63	3.15	−.5	14	9,469	nw.	53	nw.	21	12	9	7	4.8	15.4	2.4
Hartford	159	122		29.79	29.97	−.09	31.5	+4.3	63	8	39	8	13	24	42				3.89	+.1	14		nw.				9	9	10	5.4	20.7	3.9
New Haven	106	74	153	29.87	29.99	−.08	32.4	+3.4	59	8	40	10	10	25	38	29	23	71	4.15	+.2	13	6,811	w.	32	sw.	21	10	8	10	5.8	14.3	T
Middle Atlantic States							36.2	+2.8										66	2.69	−.5										5.7		
Albany	97	107	115	29.88	30.00	−.07	29.1	+5.0	57	23	36	3	9	22	37	26	19	66	2.52	+.1	9	5,943	s.	23	se.	1	6	12	10	6.0	22.7	3.6
Binghamton	871	60	68	29.04	30.00	−.08	28.4	+4.4	54	23	37	0	10	20	43				1.72	−.6	10	5,373	nw.	23	nw.	21	5	7	16	7.3	18.4	1.4
New York	314	414	454	29.65	30.00	−.08	33.8	+2.5	63	8	42	10	10	26	42	29	22	64	2.98	−.8	12	12,673	nw.	60	nw.	21	10	6	12	5.8	11.5	.0
Bellefonte	1,050	5	42	28.88	30.02		28.8		57	24	38	−1	12	19	38	24	19	72	1.09		13		w.				8	11	9	5.6	5.0	.0
Harrisburg	374	94	104	29.63	30.04	−.05	32.8	+2.6	62	24	40	10	12	25	34	27	19	60	2.40	−.6	12	6,247	nw.	35	nw.	21	12	4	12	5.4	9.9	.0
Philadelphia	114	123	367	29.92	30.05	−.05	36.7	+2.8	63	24	44	14	12	29	42	31	22	58	3.19	−.1	11	9,702	nw.	44	s.	7	10	8	10	5.1	11.8	.0
Reading	325	283	304	29.68	30.05		33.9	+5.1	61	8	43	5	13	25	46	28	20	59	2.64	−.8	12	8,579	nw.	51	nw.	21	11	7	10	5.4	10.0	.0
Scranton	805	72	103	29.15	30.05	−.03	29.8	+2.5	56	23	38	3	10	22	39	26	21	73	1.74	−1.3	11	5,655	sw.	29	nw.	21	6	12	10	5.9	14.1	T
Atlantic City	52	37	172	29.98	30.04	−.07	37.2	+3.6	64	24	45	15	6	30	26	33	26	67	4.72	+1.4	12	12,088	w.	51	nw.	8	11	4	13	5.6	7.6	.0
Sandy Hook	22	10	55	29.98	30.00		33.6		57	8	40	13	10	27	33	30	25	72	2.55	−1.2	12	11,413	nw.	46	nw.	5	10	6	12	5.2	10.5	.0
Trenton	190	159	183	29.82	30.03		33.3	+2.6	62	8	42	6	13	25	42	29	23	68	2.66	−.6	8	7,315	nw.	37	w.	21	12	5	11	5.2	10.8	.0
Baltimore	123	100	215	29.92	30.06	−.05	38.0	+2.6	68	24	46	15	9	30	41	32	25	63	2.95	−.4	12	7,934	sw.	44	sw.	21	12	6	10	5.2	10.6	.0
Washington	112	62	85	29.95	30.07	−.04	38.4	+3.1	68	24	46	14	9	30	46	31	22	58	2.63	−.6	12	5,972	nw.	32	n.	26	13	6	9	5.5	8.3	.0
Cape Henry	18	8	54	30.05	30.07		44.6	+3.4	71	24	53	22	6	36	37	40	35	71	2.90	−.3	14	9,437	nw.	43	nw.	26	9	5	14	6.1	.2	.0
Lynchburg	681	153	188	29.33	30.09	−.02	40.5	+.2	72	24	50	9	9	31	39	34	26	61	2.17	−1.0	11	5,792	nw.	41	nw.	26	13	6	9	4.9	5.9	.0
Norfolk	91	170	205	30.00	30.10	−.01	44.6	+1.9	70	24	53	17	6	36	31	39	33	69	2.52	−.7	15	9,657	w.	44	nw.	26	5	10	13	6.6	.3	.0
Richmond	144	11	52	29.94	30.10	−.01	41.2	+1.6	70	24	51	14	6	31	41	35	29	68	2.73	−.4	12	6,315	sw.	32	w.	8	9	6	13	5.7	5.7	.0
Wytheville	2,304	49	55	27.66	30.12	.00	35.6	+.5	66	24	45	−1	9	26	43	31	26	72	2.70	−.3	15	5,466	w.	28	nw.	26	7	9	12	6.2	5.0	.0
South Atlantic States							49.4	+1.5										74	4.29	+.6										6.6		
Asheville	2,253	89	104	27.71	30.14	+.01	39.3	+.8	72	24	50	0	9	29	44	35	33	83	2.90	−.2	13	6,921	nw.	32	n.	8	7	8	13	6.1	.8	.0
Charlotte	779	244	267	29.28	30.14	+.02	44.4	+.5	73	25	53	12	9	36	39	39	33	70	2.37	−1.8	10	7,804	sw.	38	w.	8	5	8	15	6.5	.3	.0
Greensboro	886	6	56	29.15	30.12		40.8		72	25	51	9	9	30	44	35	30	75	3.31		13	5,748	sw.	34	sw.	8	8	5	15	6.3	.2	.0
Hatteras	11	5	50	30.08	30.09	−.02	50.4	+3.0	68	20	58	26	6	43	25	46	42	78	5.72	+1.7	13	10,168	nw.	43	se.	11	7	8	13	6.0	T	.0
Raleigh	376	103	146	29.71	30.12	+.01	45.3	+2.1	75	25	55	16	9	36	41	39	31	63	3.37	−.6	14	6,414	nw.	34	nw.	8	8	5	15	6.2	T	.0
Wilmington	72	73	106	30.05	30.13	+.01	50.6	+2.7	74	25	60	21	6	41	27	45	40	73	5.83	+2.6	12	6,766	nw.	32	nw.	26	5	7	16	6.7	.0	.0
Charleston	48	11	92	30.08	30.13	+.01	53.8	+1.4	76	15	62	26	9	46	33	49	46	78	5.93	+3.0	11	7,272	n.	30	w.	5	7	6	15	6.8	.0	.0
Columbia, S.C.	351	41	57	29.75	30.14	+.03	49.0	+.8	75	25	58	17	9	40	38	44	39	74	3.71	−.1	12	4,949	ne.	30	sw.	5	7	5	16	6.9	.0	.0
Greenville, S.C.	1,039	139	146	29.00	30.12		44.9	+1.6	74	25	53	11	9	36	33	38	31	65	3.93	−1.2	13	6,153	sw.	35	w.	8	9	4	15	6.4	T	.0
Augusta	182	62	77	29.93	30.13	+.01	50.4	+.5	77	25	60	18	9	41	44	44	38	69	4.20	+1.1	13	4,274	nw.	24	s.	7	4	9	15	6.9	.0	.0
Savannah	65	73	152	30.06	30.13	+.01	54.5	+1.3	80	25	65	22	9	46	38	50	47	80	6.05	+2.9	13	7,302	w.	38	w.	5	7	6	15	6.8	.0	.0
Jacksonville	43	209	245	30.08	30.13	+.01	59.8	+1.8	83	20	68	24	9	52	30	54	50	78	3.23	+.3	9	7,833	n.	35	nw.	5	5	9	14	6.8	.0	.0
Florida Peninsula							71.1	+4.6										81	2.35	+.4										6.2		
Key West	22	10	64	30.08	30.10	+.03	74.4	+3.9	84	18	80	60	6	69	14	68	66	81	.75	−.6	4	6,320	e.	30	w.	28	17	7	4	3.5	.0	.0
Miami	25	124	168	30.09	30.12	+.02	72.6	+5.5	83	26	78	48	6	67	24	66	63	77	2.54	+.7	2	7,347	se.	24	se.	28	13	8	7	4.6	.0	.0
Tampa	35	88	197	30.08	30.12	+.02	66.4	+4.5	84	19	75	39	9	58	28	61	58	84	3.75	+1.2	5	7,971	s.	33	n.	8	11	8	9	5.2	.0	.0
Titusville	44	5		30.06	30.11		67.2		86	18	77	43	9	58	29				2.66		5		se.				3	22	3	5.4	.0	.0
East Gulf States							51.5	−.2										78	6.30	+1.6										7.0		
Atlanta	1,173	190	198	28.88	30.14	+.02	44.4	−.9	72	25	52	6	9	36	43	40	36	75	5.66	+.9	14	7,584	nw.	38	nw.	5	4	8	16	7.1	T	T
Macon	370	76	84	29.75	30.14	+.03	49.2	−.1	73	25	59	13	9	40	44	44	39	73	6.50	+2.1	13	4,803	nw.	25	s.	5	5	4	19	7.4	.0	.0
Thomasville	273	49	103	29.84	30.15	+.02	55.8	+.8	81	24	65	18	9	46	35	51	48	81	8.16	+3.7	16	5,878	ne.	25	nw.	8	6	5	17	6.9	.0	.0
Apalachicola	36	11	51	30.08			56.8		76	25	64	23	9	49	34	54	51	85	6.43	+2.5	15	6,310	e.	32	ne.	28	6	7	15	6.5	.0	.0
Pensacola	56	149	185	30.08	30.14	+.03	55.4	+.2	74	18	63	17	9	48	40	52	50	80	5.80	+1.5	13	8,432	ne.	38	e.	28	4	9	15	6.8	.0	.0
Anniston	741	9	57																													
Birmingham	700	11	48	29.37	30.15	+.03	46.9	−1.1	76	25	56	7	9	38	31	42	38	74	5.64	+.6	17	5,590	n.	30	s.	7	4	5	19	7.4	T	.0
Mobile	57	125	161	30.07	30.13	+.02	54.4	−.3	78	18	62	17	9	46	40	49	46	80	6.88	+1.6	15	6,872	s.	29	e.	28	4	10	14	6.9	.0	.0
Montgomery	223	100	112	29.90	30.16	+.04	51.5	−.1	79	25	60	13	9	43	38	46	41	73	5.65	+.2	15	5,522	se.	31	nw.	7	4	7	17	7.3	T	.0
Corinth	469	6					44.8		76	24	55	3	9	35	37				7.33		14		se.				4	14	10		1.5	.0
Meridian	375	87	95	29.74	30.15	+.04	49.4	−.2	79	14	58	10	9	40	31	44	40	74	4.94	−.5	16	4,757	nw.	22	nw.	7	4	8	16	7.0	T	.0
Vicksburg	247	65	73	29.87	30.13	+.04	52.8	−1.6	78	24	58	14	9	42	30	46	41	77	8.06	+3.2	18	5,665	se.	24	w.	7	5	6	17	7.4	.3	.0
New Orleans	53	76	84	30.07	30.13	+.04	58.1	+.8	83	25	66	20	9	50	28	52	49	78	5.62	+1.4	13	5,409	ne.	22	ne.	28	5	10	13	6.6	.0	.0
West Gulf States							49.6	−1.9										77	2.80	+.3										6.6		
Shreveport	249	92	227	29.86	30.14	+.05	49.2	−1.7	79	24	58	9	8	41	49	45	41	77	6.72	+3.4	15	7,528	ne.	34	nw.	7	7	5	16	6.8	.6	.0
Bentonville	1,303	11	44	28.68	30.08	−.02	36.6	−1.9	75	23	48	−10	8	26	43				1.76		7	5,037	s.	21	s.	6	10	5	13		1.1	.0
Fort Smith	457	79	94	29.63	30.13	+.03	41.4	−1.4	78	23	52	−3	8	31	38	35	29	68	1.89	−.7	8	6,145	e.	30	nw.	25	12	5	11	5.4	1.1	.0
Little Rock	357	136	153	29.76	30.16	+.05	42.0	−2.9	76	24	51	4	8	33	40	37	30	66	2.66	−1.2	11	5,774	e.	24	nw.	20	8	5	15	5.4	2.7	.0
Austin	605	136	148	29.47	30.11		50.5	−2.9	82	23	60	11	8	41	48	45	41	75	2.22	−.1	12	6,115	n.	28	n.	7	5	9	14	6.6	T	.0
Brownsville	57	83	100	29.99	30.04		63.6	+1.0	83	1	72	29	8	56	26	58	56	83	.84	−.4	8	7,718	se.	31	nw.	7	5	13	10	6.6	.0	.0
Corpus Christi	20	11	78	30.07	30.10	+.05	56.6	−1.8	76	14	63	22	8	50	43	54	52	87	1.89	+.4	15	7,281	se.	31	n.	8	5	10	13	6.5	.0	.0
Dallas	512	220	227	29.56	30.12		45.7		79	23	55	2	8	36	50				2.62	+.3	13	8,881	n.	29	n.	7	3	3	22	8.2	.0	.0
Fort Worth	670	106	114	29.39	30.12	+.05	46.8	−1.5	86	23	58	2	8	36	50	40	33	65	2.47	+.7	13	6,367	se.	40	nw.	7	10	3	15	6.5	2.3	.0
Galveston	54	106	114	30.05	30.11	+.04	55.0	−1.3	74	23	61	19	8	48	40	52	51	89	4.34	+1.5	14	7,932	nw.	32	nw.	7	10	3	15	6.1	.3	.0
Houston	138	292	314	29.97	30.14		53.7	−2.2	79	25	62	13	8	46	49				3.28	+.1	13	9,003	n.	34	sw.	7	3	8	17	7.8	T	.0
Palestine	510	64	72	29.60	30.14	+.06	48.4	−2.8	79	24	58	5	8	39	54	43	39	75	2.98	−.1	11	5,914	n.	38	nw.	8	4	9	15	7.4	.0	.0
Port Arthur	34	58	66	30.08	30.12		54.8		77	2	62	18	9	48	40	49	47	87	2.87	−.7	13	6,637	s.	30	nw.	7	9	7	12	6.6	.3	.0
San Antonio	693	242	301	29.36	30.09	+.04	52.8	−2.6	80	24	62	14	8	48	49	48	43	75	1.92	+.3	13	6,926	n.	29	nw.	8	2	13	13	6.9	T	.0
Taylor	571	38	51	29.53	30.15	+.09	48.8	−2.5	82	23	59	9	8	39	48				2.45	+.3	13	6,359	n.	29	nw.	7	7	8	13	6.1	T	.0

TABLE I.—*Climatological data for Weather Bureau stations, February 1933*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation: Thermometer above ground	Elevation: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature: Mean max. + mean min. ÷ 2	Temperature: Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Days with 0.01, or more	Wind: Total movement	Prevailing direction	Maximum velocity: Miles per hour	Maximum velocity: Direction	Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	° F.	° F.	° F		° F	° F.		° F	° F.	° F.	° F.	%	In.	In.		Miles								0-10	In.	In.
Ohio Valley and Tennessee							36.3	+0.2										68	3.38	0.0										5.6		
Chattanooga	762	190	215	29.33	30.17	+0.04	43.6	−0.5	71	23	52	4	9	35	41	38	31	66	6.52	+1.6	15	6,084	se.	30	nw.	5	5	8	15	6.8	1.6	0.0
Knoxville	995	79	97	29.06	30.14	+.02	40.8	−1.1	70	24	50	3	9	32	40	35	29	70	7.11	+2.6	15	4,801	ne.	24	nw.	5	6	7	15	6.4	4.8	.0
Memphis	399	78	86	29.71	30.15	+.04	42.8	−1.5	73	24	51	6	8	35	41	38	32	69	5.07	+.7	13	5,781	sw.	30	nw.	7	8	6	14	6.6	2.5	.0
Nashville	546	168	191	29.57	30.17	+.05	41.1	−.5	71	24	50	2	9	32	40	36	31	73	6.21	+2.1	12	7,165	s.	31	w.	4	6	10	12	6.3	3.8	.0
Lexington	989	193	230	29.05	30.16	+.05	35.2	−.2	67	24	44	−5	9	27	32	----	----	----	3.36	−.3	14	9,717	s.	35	s.	7	15	4	9	4.2	4.0	.0
Louisville	525	188	234	29.55	30.15	+.04	36.8	−.4	69	24	46	−1	9	28	36	32	25	67	3.00	−.6	11	7,851	s.	36	s.	22	12	6	10	5.2	3.8	.0
Evansville	431	76	116	29.66	30.15	+.04	36.0	−.3	66	23	44	0	9	28	36	31	25	66	3.10	−.1	13	7,070	s.	37	s.	22	12	4	12	5.3	4.2	.0
Indianapolis	822	194	230	29.18	30.10	.00	31.0	−.1	63	24	40	−10	9	22	28	27	20	64	1.90	−.8	12	8,324	w.	32	sw.	22	10	7	11	5.3	2.6	.0
Terre Haute	575	96	129	29.47	30.11	----	32.0	----	67	24	41	−7	9	23	33	28	22	70	2.13	−.5	11	7,342	s.	35	sw.	22	13	8	7	4.5	2.1	.0
Cincinnati	627	11	51	29.42	30.12	+.02	34.2	+1.4	66	24	44	−6	9	25	27	29	24	70	1.99	−1.0	13	6,534	s.	30	sw.	22	12	4	12	5.4	4.1	.0
Columbus	822	216	230	29.19	30.09	.00	32.4	+1.7	60	24	41	−6	9	24	30	28	22	69	1.37	−1.3	11	9,378	sw.	46	w.	21	8	12	8	5.4	2.7	.0
Dayton	899	137	173	29.11	30.10	----	32.4	+1.0	61	24	41	−7	9	24	28	28	23	71	2.04	−.6	13	7,250	sw.	36	sw.	22	11	7	10	5.1	3.2	.0
Elkins	1,947	59	67	28.00	30.13	+.03	32.8	+1.2	60	24	44	−4	9	22	50	28	22	70	3.35	+.3	16	5,757	w.	32	w.	26	6	8	14	6.5	7.5	.0
Parkersburg	637	77	82	29.46	30.14	+.04	35.5	+1.3	65	24	45	−2	9	26	39	30	24	67	1.92	−1.2	11	5,451	se.	34	nw.	21	13	6	9	5.1	3.0	.0
Pittsburgh	842	353	410	29.15	30.08	−.01	33.0	+.7	60	22	42	−3	9	24	44	28	21	66	1.67	−1.0	12	8,944	w.	43	nw.	26	6	7	15	6.5	5.4	.0
Lower Lake Region							28.4	+3.5										71	1.75	−.7										6.3		
Buffalo	767	243	280	29.12	29.98	−.08	27.4	+3.1	53	22	35	−4	9	20	40	24	20	77	2.48	−.5	17	13,438	sw.	54	sw.	23	6	10	12	6.7	17.7	1.8
Canton	448	10	61	29.44	29.93	----	23.4	+5.4	47	23	32	−13	9	14	52	----	----	----	2.18	−.1	19	7,865	sw.	38	w.	16	3	9	16	7.3	12.8	3.7
Ithaca	836	74	100	29.05	29.99	----	28.8	+4.3	54	23	38	−1	10	20	39	25	19	69	1.34	−.6	10	9,085	nw.	32	nw.	8	5	13	10	6.5	17.0	2.1
Oswego	335	71	85	29.59	29.97	−.09	28.2	+4.3	48	8	36	−3	9	21	44	25	20	73	1.81	−.9	16	9,518	s.	37	w.	21	2	9	17	7.5	21.2	2.4
Rochester	523	86	102	29.39	29.98	−.08	28.6	+4.0	56	22	36	−2	9	21	42	24	18	67	1.63	−1.1	14	7,982	w.	40	w.	21	4	10	14	6.9	10.7	2.0
Syracuse	596	65	79	29.32	29.99	−.08	29.4	+5.6	52	23	37	0	9	22	42	----	----	----	1.74	−1.0	15	6,818	w.	25	sw.	21	3	6	19	8.1	14.1	1.0
Erie	714	130	166	29.22	30.01	−.06	29.6	+2.7	58	22	37	−3	9	22	39	26	22	75	1.31	−1.3	13	11,523	w.	46	sw.	9	10	5	13	5.9	3.8	.0
Cleveland	762	267	337	29.18	30.03	−.04	31.2	+3.8	60	22	39	−5	9	23	34	26	20	67	1.99	−.5	12	11,682	w.	53	w.	26	7	9	12	6.2	8.4	.0
Sandusky	629	5	67	29.35	30.06	−.01	30.4	+3.0	58	22	39	−5	9	22	30	----	----	----	1.45	−.7	9	8,307	sw.	34	w.	21	7	11	10	5.6	1.3	.0
Toledo	628	79	87	29.34	30.04	−.03	28.6	+1.3	57	22	37	−11	9	20	29	25	18	66	1.95	−.1	9	8,229	w.	36	nw.	25	13	10	5	4.4	3.6	.0
Fort Wayne	856	69	84	29.10	30.06	----	28.0	+2.2	58	22	36	−14	9	20	29	25	19	69	1.68	−.7	8	8,145	w.	33	w.	21	13	5	10	5.0	2.1	.0
Detroit	730	218	258	29.20	30.02	−.04	27.4	+2.1	55	22	36	−12	9	19	31	24	20	75	1.49	−.7	9	8,900	sw.	38	sw.	1	9	8	11	5.7	4.4	.0
Upper Lake Region							19.4	+.1										80	1.84	.0										6.5		
Alpena	609	13	89	29.26	29.96	−.07	19.8	+1.8	46	22	28	−9	9	12	30	17	14	83	1.50	−.2	11	8,831	nw.	35	nw.	21	7	10	11	6.1	15.0	.6
Escanaba	612	54	60	29.27	29.97	−.09	15.0	−.4	47	28	23	−26	9	7	38	13	10	80	1.59	+.1	11	7,383	nw.	28	ne.	7	6	11	11	6.0	14.1	2.5
Grand Haven	632	54	89	29.30	30.01	−.04	24.3	+.1	49	24	31	−11	9	17	25	23	20	84	2.18	.0	16	10,009	w.	43	w.	21	3	7	18	7.9	16.1	T
Grand Rapids	707	70	244	29.20	30.00	−.05	24.8	+1.1	54	22	32	−11	9	17	29	22	18	77	1.97	−.3	14	9,671	w.	45	w.	20	5	5	18	6.9	21.1	.0
Houghton	668	64	99	29.20	29.96	−.09	12.8	−.9	40	27	21	−24	9	5	36	----	----	----	3.05	+1.3	19	7,308	w.	30	w.	17	2	8	18	7.9	30.4	26.5
Lansing	878	6	88	29.03	30.00	----	23.4	+.5	53	22	32	−14	9	15	28	21	20	89	1.71	−.2	10	8,335	sw.	32	nw.	25	8	10	10	5.7	8.7	.0
Ludington	637	60	66	29.26	29.98	----	22.7	+.2	48	24	29	−15	9	16	25	21	18	81	1.75	−.3	17	9,594	w.	37	w.	20	7	3	18	6.8	12.3	.0
Marquette	734	77	111	29.10	29.94	−.11	15.7	−.6	45	28	23	−26	9	8	27	14	10	81	3.44	+1.5	13	7,942	w.	37	sw.	15	5	7	16	7.0	35.3	10.5
Port Huron	638	79	120	29.27	29.99	−.06	25.0	+2.3	52	22	33	−12	9	17	30	22	18	76	1.90	.0	9	9,243	sw.	38	w.	21	6	9	13	6.2	7.1	.0
Sault Ste Marie	614	11	52	29.22	29.96	−.07	15.0	+2.4	40	28	23	−15	8	6	35	13	11	89	2.38	+.4	20	6,563	se.	49	nw.	21	7	4	17	6.6	27.9	4.6
Chicago	673	7	131	29.30	30.06	−.02	26.2	−.1	56	25	34	−19	9	18	28	23	17	68	1.22	−.9	4	8,603	sw.	35	sw.	1	12	8	8	4.9	12.7	.0
Green Bay	617	109	141	29.29	29.99	−.07	18.0	+.6	47	22	26	−26	9	10	34	15	10	70	.75	−.8	9	8,802	w.	35	ne.	7	6	8	14	6.7	4.1	.0
Milwaukee	681	97	221	29.26	30.03	−.03	22.0	−.8	53	23	29	−22	9	14	28	19	14	73	1.43	−.4	9	10,078	w.	38	n.	7	7	10	11	5.7	13.8	T
Duluth	1,133	5	47	28.69	29.98	−.10	6.8	−4.6	39	27	17	−33	9	−3	32	5	2	84	.90	−.2	8	10,022	w.	41	nw.	20	8	5	15	6.2	10.9	2.5
North Dakota							8.4	+.6										84	.29	−.2										5.3		
Moorhead	940	50	58	28.97	30.05	−.06	7.4	−.7	46	27	16	−31	7	−2	44	6	5	91	.43	−.3	9	6,796	nw.	30	nw.	10	8	7	13	6.1	5.7	.3
Bismarck	1,674	8	57	28.16	30.04	−.08	10.6	+.3	54	26	21	−38	7	0	51	9	5	79	.22	−.2	5	6,659	nw.	31	nw.	10	13	10	5	4.3	3.3	T
Devils Lake	1,478	11	44	28.34	30.01	−.10	5.8	+.7	44	26	15	−35	7	−4	53	4	2	89	.11	−.4	6	7,314	w.	31	nw.	10	7	10	11	6.0	1.1	.3
Ellendale	1,457	10	56	28.37	30.01	----	11.0	----	56	26	22	−32	7	0	50	----	----	----	.07	−.5	3	9,524	nw.	40	nw.	10	10	6	12	5.6	1.4	.0
Grand Forks	833	12	67	----	----	----	5.6	----	43	27	15	−33	7	−4	40	4	----	----	.13	----	5	----	nw.	28	se.	5	4	17	7	----	1.5	1.3
Williston	1,878	41	48	27.95	30.04	−.07	10.0	+1.9	44	26	20	−35	8	0	43	8	3	75	.61	+.2	5	6,480	w.	35	w.	27	12	10	6	4.5	5.9	T
Upper Mississippi Valley							24.5	−.1										72	.95	−.7										4.6		
Minneapolis	918	102	208	29.00	30.04	----	14.2	−1.7	46	23	24	−28	8	5	41	----	----	----	.77	−.2	8	8,505	w.	32	w.	20	8	10	10	5.8	8.9	T
St. Paul	837	114	149	29.08	30.03	−.06	13.8	−2.0	48	23	24	−28	9	4	41	----	----	----	.87	.0	6	7,264	nw.	32	nw.	20	10	6	12	5.6	10.3	T
La Crosse	714	11	48	29.24	30.05	−.03	18.0	−1.2	55	23	28	−25	9	8	38	15	11	79	.62	−.4	8	4,947	w.	22	sw.	10	9	9	10	5.4	5.0	.0
Madison	974	70	78	28.94	30.05	−.02	18.9	−.2	54	23	28	−26	9	10	33	16	13	79	.86	−.6	6	7,343	nw.	29	n.	7	12	6	10	5.0	6.0	0
Wausau	1,247	4	62	28.60	30.00	----	12.4	----	44	22	22	−31	9	3	33	----	----	----	1.07	−.1	10	5,765	w.	28	w.	20	12	7	9	5.0	6.2	1.0
Charles City	1,015	10	51	28.95	30.08	−.02	18.0	+.9	56	23	29	−25	9	7	38	15	11	80	.31	−.8	5	6,053	nw.	24	w.	20	14	8	6	4.0	3.0	.0
Davenport	606	118	143	29.40	30.10	.00	25.2	+.6	63	23	35	−20	9	16	28	21	16	71	.64	−.9	4	8,710	nw.	45	sw.	22	14	7	7	4.6	6.6	.0
Des Moines	861	5	99	29.15	30.10	−.01	24.3	+.3	63	23	34	−19	9	14	33	20	14	68	.16	−1.0	4	7,842	nw.	32	w.	19	15	7	6	4.2	2.3	.0
Dubuque	700	81	96	29.29	30.07	−.02	21.4	−.8	60	23	31	−23	9	12	35	18	13	72	.54	−.8	4	5,932	nw.	27	nw.	20	15	4	9	4.5	5.2	.0
Keokuk	614	64	78	29.42	30.13	+.02	28.0	−.3	65	23	38	−16	9	18	34	23	16	65	.65	−.9	2	6,307	sw.	27	sw.	22	14	8	6	4.0	5.8	.0
Cairo	358	87	93	29.75	30.14	+.02	37.8	−.7	70	24	46	1	9	30	38	33	27	69	3.77	+.6	12	6,665	s.	31	s.	22	8	7	13	6.1	3.8	.0
Peoria	609	11	45	29.42	30.12	+.02	26.8	+.9	63	23	37	−19	9	17	36	22	18	75	1.33	−.7	3	5,858	nw.	28	sw.	1	15	6	7	3.9	10.9	.0
Springfield, Ill	636	5	191	29.40	30.10	.00	30.8	+1.3	66	24	40	−10	9	22	34	26	20	67	1.19	−1.1	7	8,505	s.	37	s.	12	14	6	8	4.2	2.2	.0
Hannibal	534	74	109	29.52	30.12	+.01	30.4	+.7	70	23	40	−11	9	21	33	----	----	----	.44	−1.4	6	6,565	nw.	32	sw.	22	15	5	8	4.0	3.3	.0
St. Louis	568	265	303	29.49	30.12	+.01	35.1	+.6	71	23	44	−5	8	26	41	29	22	63	.96	−1.6	5	8,748	nw.	47	sw.	12	11	9	8	4.4	1.5	.0
Missouri Valley							26.2	+.4										64	.45	−.7										4.0		
Columbia, Mo	784	6	84	29.26	30.13	+.02	31.6	−.1	73	23	41	−10	8	22	33	----	----	----	.97	−1.1	6	6,118	w.	27	s.	22	13	8	7	4.0	4.5	.0
Kansas City	963	10	86	29.06	30.13	+.02	32.1	+.9	73	23	42	−13	8	23	48	26	16	55	.93	−.8	5	7,083	nw.	32	w.	4	14	9	5	3.6	6.6	.0
St. Joseph	967	11	49	29.04	30.11	----	29.8	----	72	24	40	−15	8	19	47	23	15	62	.31	−1.1	4	6,638	nw.	31	w.	22	16	6	6	3.6	2.7	.0
Springfield, Mo	1,324	98	104	28.67	30.12	+.01	34.5	−.7	74	23	44	−13	8	25	37	29	24	70	1.09	−1.3	6	7,476	s.	31	w.	4	13	4	11	4.9	1.8	.0
Iola	984	11	50	29.03	30.13	+.03	34.0	+.8	74	24	46	−11	8	22	36	----	----	----	.46	−1.2	4	----	n.	----	----	----	13	5	10	----	1.5	.0
Topeka	987	92	107	----	----	----	31.2	+.2	72	24	42	−14	8	20	50	----	----	----	.49	−1.0	4	6,394	n.	32	nw.	4	14	10	4	3.2	5.9	.0
Lincoln	1,189	11	81	28.78	30.10	.00	27.2	+1.1	65	23	39	−18	8	16	47	21	13	61	.29	−.7	6	7,524	s.	37	w.	22	17	5	6	3.6	3.6	.0
Omaha	1,105	115	122	28.88	30.11	.00	26.0	+.5	65	23	36	−18	8	16	42	21	12	58	.25	−.6	5	6,750	nw.	38	n.	6	17	4	7	3.5	5.1	.0
Valentine	2,598	47	54	27.27	30.12	+.03	20.4	−1.0	61	21	34	−25	8	6	54	16	10	71	.19	−.4	5	6,550	w.	32	nw.	4	11	10	7	4.5	2.4	.0
Sioux City	1,135	94	164	28.82	30.10	−.02	21.2	+.2	59	23	32	−23	9	11	40	17	11	68	.20	−.6	6	8,110	nw.	30	n.	6	12	11	5	4.4	3.4	.0
Huron	1,306	59	74	28.62	30.09	−.03	16.9	+2.6	57	26	29	−25	7	5	49	12	7	74	.21	−.3	7	7,032	w.	28	n.	6	14	12	2	4.1	3.3	.0
Pierre	1,572	70	75	28.34	30.09	−.02	19.8	+1.2	62	26	32	−24	7	8	53	15	6	56	.25	−.2	3	6,220	nw.	30	n.	6	11	14	3	4.0	3.3	.0
Yankton	1,233	49	57	28.70	30.09	−.03	20.0	−.9	59	23	32	−24	8	8	54	----	----	----	.18	−.6	3	5,689	w.	24	w.	19	12	11	5	4.3	4.1	.0

TABLE I.—*Climatological data for Weather Bureau stations, February 1933*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max.+mean min.÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	° F.	° F.	° F		° F.	° F.		° F	° F.	° F.	° F.	%	In.	In.		Miles								0–10	In.	In.
Northern Slope							18.1	−3.7										70	0.51	−0.2										5.7		
Billings	3,140	5	----				20.1		55	26	33	−40	7	7	48				0.63		7		nw.				6	9	13		8.5	0.0
Havre	2,505	11	67	27.31	30.12	+0.05	16.0	+2.4	59	26	27	−32	7	5	44	14	10	80	.27	−0.2	4	8,411	sw.	35	sw.	25	5	15	8	6.0	3.9	.0
Helena	4,124	89	113	25.75	30.12	+.01	18.6	−4.4	51	26	28	−35	9	10	41	16	9	66	.82	+.2	9	6,294	sw.	38	sw.	20	1	9	18	7.7	16.9	T
Kalispell	2,973	48	56	26.95	30.14	+.06	18.9	−4.4	46	26	27	−31	9	11	27	18	14	80	1.25	+.1	11	3,978	nw.	28	sw.	22	2	7	19	7.8	14.9	5.3
Miles City	2,371	48	55	27.45	30.12	+.03	15.3	−1.5	48	25	26	−35	7	4	41	14	10	77	.18	−.3	7	4,511	s.	26	nw.	4	10	10	8	5.1	2.0	.2
Rapid City	3,259	50	58	26.54	30.11	+.03	20.4	−3.0	58	26	32	−28	7	9	43	17	10	66	.35	−.1	5	5,927	nw.	38	nw.	4	8	14	6	4.9	4.5	.0
Cheyenne	6,088	84	101	23.87	30.06	+.03	21.6	−5.7	54	26	34	−22	7	10	57	15	4	50	.30	−.3	6	11,050	w.	56	w.	22	10	12	6	4.8	4.9	T
Lander	5,372	60	68	24.54	30.12	+.04	16.2	−6.3	50	28	31	−38	9	1	46	13	9	76	.38	−.2	6	3,661	sw.	35	sw.	23	19	7	2	2.9	4.9	T
Sheridan	3,790	10	47	26.03	30.10		16.6		48	25	29	−33	7	4	42	13	7	69	.64	−.1	5	4,250	nw.	30	nw.	5	6	13	9	5.8	7.9	.3
Yellowstone Park	6,241	11	48	23.78	30.21	+.11	10.2	−9.4	37	28	19	−40	9	1	34	8	4	74	.76	−.6	14	6,946	sw.	32	sw.	22	4	5	19	7.8	12.4	11.0
North Platte	2,821	11	51	27.05	30.10	+.03	25.4	−1.2	63	21	40	−19	8	11	46	19	10	62	.15	−.4	3	5,959	w.	29	nw.	4	13	11	4	3.8	1.8	.0
Middle Slope							32.3	−1.5										52	.44	−.4										4.0		
Denver	5,292	106	113	24.63	30.03	+.02	29.2	−3.5	67	23	42	−16	8	16	47	20	2	37	.23	−.3	4	6,241	s.	28	ne.	6	17	7	4	3.2	5.4	.0
Pueblo	4,685	80	86	25.23	30.04	+.04	30.5	−2.4	69	23	46	−24	8	15	50	22	7	43	.36	−.1	4	5,914	w.	31	nw.	22	15	9	4	3.6	4.3	.0
Concordia	1,392	50	58	28.61	30.14	+.05	30.4	+.6	67	23	43	−17	8	18	49	23	14	60	.11	−.8	4	6,245	n.	37	nw.	4	16	5	7	3.6	1.1	.0
Dodge City	2,509	10	86	27.43	30.12	+.06	31.5	−1.7	69	23	46	−17	8	16	50	23	10	51	.17	−.6	5	8,453	n.	39	sw.	18	15	8	5	3.5	.8	.0
Wichita	1,358	85	93	28.64	30.12	+.04	33.6	−.8	73	23	45	−12	8	22	54	26	16	55	.34	−.9	4	7,335	n.	32	s.	21	12	6	10	4.8	3.5	.0
Oklahoma City	1,214	10	47	28.80	30.12	+.05	38.4	−1.2	75	23	50	−5	8	27	56	32	24	63	1.42	+.3	6	6,366	n.	32	n.	7	10	9	9	5.0	2.0	.0
Southern Slope							43.1	−2.8										57	.68	.0										5.1		
Abilene	1,738	10	52	28.27	30.11	+.06	45.0	−2.2	84	23	58	−5	8	32	42	37	27	58	1.41	+.4	5	6,907	s.	28	sw.	6	7	7	14	6.2	1.3	.0
Amarillo	3,676	10	49	26.26	30.08	+.06	36.9	−1.2	74	23	51	−8	7	23	65	27	11	44	.29	−.4	3	6,447	sw.	27	s.	18	14	9	5	4.1	2.8	.0
Big Spring	2,537	5	62	27.43	30.11		44.2		80	23	59	−7	8	30	46	35	27	63	.61		6		s.				8	8	12	5.7	.9	.0
Del Rio	944	64	71	29.05	30.06	+.06	53.1	−2.9	82	23	64	14	8	42	37	46	39	65	.61	+.1	7	6,157	se.	28	n.	7	8	7	13	5.9	.0	.0
Roswell	3,566	75	85	26.39	30.08	+.10	37.4	−5.1	72	23	53	−24	8	22	48	30	19	56	.39	−.2	4	5,299	n.	32	se.	18	16	7	5	3.7	4.3	.0
Southern Plateau							38.2	−6.6										47	.14	−.5										2.9		
El Paso	3,778	152	175	26.19	30.03	+.08	46.6	−2.4	72	23	59	14	8	34	39	36	23	43	.23	−.2	5	7,246	nw.	50	w.	7	16	7	5	3.4	.1	.0
Albuquerque	4,972	51	66	25.05	30.08		31.9		63	28	47	−4	8	17	45	24	7	39	.01	−.1	1	6,471	n.	36	w.	18	16	8	4	3.5	T	.0
Santa Fe	7,013	38	53	23.18	30.08	+.10	27.2	−5.9	58	28	38	−10	8	16	33	21	9	48	.21	−.5	6	4,931	n.	21	n.	4	13	9	6	3.7	3.5	.0
Flagstaff	6,907	10	59	23.29	30.06	+.10	20.4	−10.4	54	28	36	−17	8	5	50	19		74	.91		5	5,846	n.	33	nw.	7	16	9	3		7.5	T
Phoenix	1,108	10	107	28.88	30.06	+.07	49.6	−5.5	78	28	64	24	8	36	40	39	24	43	.15	−.6	2	3,732	e.	22	nw.	10	19	3	6	2.5	.0	.0
Yuma	141	9	54	29.95	30.10	+.10	53.0	−5.6	78	28	66	29	8	40	38	41	21	33	.12	−.3	1	5,099	n.	26	n.	7	24	3	1	1.3	.0	.0
Independence	3,957	6	27	26.07	30.21	+.15	32.7	−9.5	61	27	45	8	10	21	33	26			.01	−.8	1		n.				22	6	0		T	.0
Middle Plateau							20.3	−13.0										70	.43	−.6										3.9		
Reno	4,532	74	81	25.56	30.24	+.16	28.7	−6.9	58	28	42	−2	10	16	37	25	16	59	.20	−1.0	3	4,490	sw.	32	sw.	8	16	9	3	3.4	2.5	.0
Tonopah	6,090	12	20				22.1		48	26	30	−7	10	14	27	18	14	70	.07		1											
Winnemucca	4,344	18	56	25.74	30.31	+.22	17.8	−15.7	53	28	34	−26	10	2	41	17	12	75	.64	−.3	7	5,142	ne.	34	nw.	23	12	10	6	4.5	9.2	.1
Modena	5,473	10	46	24.64	30.20	+.16	16.8	−14.2	53	28	32	−27	10	2	43	15	10	74	.04	−.9	2	6,476	w.	32	nw.	6	20	6	2	2.2	.7	.2
Salt Lake City	4,360	163	203	25.70	30.22	+.14	21.9	−11.9	51	28	31	−10	10	13	30	19	13	64	.99	−.5	9	4,262	nw.	24	w.	6	9	7	12	5.8	15.9	4.0
Grand Junction	4,602	60	68	25.44	30.18	+.14	16.5	−16.4	55	28	30	−21	8	3	36	14	10	77	.27	−.3	4	3,042	nw.	17	se.	24	15	7	6	3.8	3.4	.0
Northern Plateau							24.6	−8.7										71	1.03	−.4										7.0		
Baker	3,471	48	53	26.54	30.28	+.16	17.3	−11.7	42	22	27	−25	9	8	31	16	11	72	1.33	+.1	15	5,088	se.	21	se.	25	5	8	15	7.0	14.8	2.4
Boise	2,739	79	87	27.32	30.30	+.18	22.8	−12.0	57	28	32	−13	9	14	27	21	17	77	1.51	+.1	12	3,761	se.	24	n.	6	5	6	17	6.9	18.2	.0
Lewiston	757	40	48	29.38	30.22	+.11	30.0	−7.0	56	22	38	−7	13	22	26				1.23	−.1	5	3,646	e.	21	n.	6	4	5	19	8.0	6.7	.0
Pocatello	4,477	60	68	25.52	30.25	+.15	17.6	−11.3	45	28	27	−28	9	8	39	16	13	78	.41	−.9	11	6,961	sw.	32	sw.	19	5	9	14	6.8	6.8	.6
Spokane	1,929	101	110	28.05	30.19	+.10	23.3	−8.0	46	20	30	−17	9	16	26	21	16	73	.60	−1.2	10	5,172	s.	25	sw.	26	4	9	15	7.2	9.8	T
Walla Walla	991	57	65	29.10	30.21	+.10	31.8	−5.3	59	25	39	−3	9	25	25	27	20	63	1.73	.0	9	4,648	s.	26	w.	21	4	9	15	7.2	12.9	.0
Yakima	1,076	58	67	29.00	30.20		29.1	−5.4	57	25	39	−9	9	19	33	26	18	62	.38	−.6	5	3,568	w.	27	w.	22	7	12	9	6.0	4.6	T
North Pacific Coast Region							38.7	−3.2										77	3.42	−1.9										7.7		
North Head	211	11	56	29.95	30.18	+.12	39.4	−3.6	49	4	44	15	9	35	24	38	35	85	4.95	−2.5	21	9,897	s.	55	s.	25	4	7	17	7.5	T	.0
Port Angeles	29	8	53		30.16		36.5		54	22	43	12	9	30	18				1.85	−1.4	10	5,118	s.	35	n.	8	1	12	15		.1	.0
Seattle	125	215	250	30.03	30.16	+.10	37.5	−3.6	54	25	42	16	9	33	20	35	29	73	2.17	−1.7	13	6,948	se.	40	sw.	25	6	2	20	7.5	1.0	.0
Tacoma	194	172	201	29.96	30.18	+.12	37.1	−3.5	55	25	43	11	9	32	19				2.77	−1.9	13	6,734	s.	32	s.	25	4	9	15	7.5	5.3	.0
Tatoosh Island	86	9	53	30.02	30.12	+.12	39.3	−1.7	47	21	42	23	8	36	15	36	32	78	8.01	−1.4	17	11,824	e.	45	s.	24	3	7	18	7.5	3.6	.0
Medford	1,329	29	58	28.80	30.26		37.7		56	20	47	17	10	28	30	35	30	72	1.15	−1.2	7	3,442	n.	24	nw.	23	5	9	14	7.0	.1	.0
Portland, Oreg	153	68	106	30.06	30.22	+.14	38.2	−3.9	58	25	44	12	9	33	22	36	32	78	4.26	−1.1	18	4,937	sw.	24	e.	8	2	0	26	9.0	2.4	.0
Roseburg	510	75	99	29.69	30.25	+.15	40.7	−2.7	64	25	48	17	9	33	29	38	33	74	2.22	−2.3	14	3,424	sw.	21	n.	8	2	7	19	8.0	.7	.0
Middle Pacific Coast Region							47.5	−2.4										72	1.29	−2.7										4.0		
Eureka	62	73	89	30.21	30.28	+.17	44.4	−2.8	63	4	51	32	24	38	23	44	42	90	2.98	−3.5	13	4,576	se.	22	n.	16	11	6	11	5.2	.0	.0
Red Bluff	330	5	58	29.86	30.22	+.11	46.4	−3.0	72	25	57	27	10	36	32	41	33	64	.97	−3.0	4	4,875	n.	24	nw.	24	11	8	9	4.8	4.2	.0
Sacramento	69	106	117	30.13	30.20	+.11	47.2	−2.9	65	22	57	29	10	38	28	42	35	65	.95	−2.1	4	5,676	nw.	24	nw.	24	19	7	2	2.7	.0	.0
San Francisco	155	208	243	30.04	30.21	+.11	51.2	−1.0	65	25	58	40	2	44	20	45	39	67	1.13	−2.7	3	4,849	w.	28	n.	24	14	9	5	3.9	.0	.0
San Jose	141	12	110	30.06	30.22		48.4	−2.2	65	25	59	29	10	38	30				.40	−2.0	3	4,167	nw.	25	nw.	23	14	12	2	3.4	.0	.0
South Pacific Coast Region							52.6	−1.3										58	.16	−2.0										2.5		
Fresno	327	89	98	29.83	30.20	+.12	49.0	−2.1	70	22	60	30	10	38	31	42	34	60	.45	−1.0	2	3,988	nw.	25	nw.	23	16	9	3	3.2	.0	.0
Los Angeles	338	159	191	29.75	30.12	+.06	56.0	+.5	75	20	66	42	9	46	27	45	34	50	.00	−3.1	0	4,240	ne.	22	ne.	24	24	4	0	1.2	.0	.0
San Diego	87	62	70	30.01	30.11	+.05	52.7	−2.4	68	21	61	39	4	44	24	46	40	64	.02	−2.0	1	4,037	nw.	19	nw.	24	19	5	4	3.0	.0	.0
West Indies																																
San Juan, P.R	82	9	54	29.97	30.06		75.0	+.1	84	27	80	67	26	70	16				.71	−2.0	10	9,017	e.	29	ne.	11	9	19	0	4.4	.0	.0
Panama Canal																																
Balboa Heights	118	6	97		[1]29.86	.00	79.8	−.5	90	20	88	68	24	71	20			[1]74	.30	−.4	3	6,428	nw.	25	n.	23	10	16	2	4.3	.0	.0
Cristobal	36	6	97		[1]29.89	.00	81.2	+.4	87	7	85	75	25	78	9	74	71	[1]75	.08	−1.5	7	10,752	n.	26	ne.	13	9	16	3	4.7	.0	.0
Alaska																																
Fairbanks	455	11	44	[2]29.55	[2]30.12		−6.8		28	8	4	−49	23	−18	37	−4	−8	81	.65		8	1,636	n.	15	sw.	15	7	6	15	6.4	12.4	23.5
Juneau	80	11	50	[2]29.84	[2]29.93		28.6		42	3	33	13	28	24	21	27	24	79	6.67		18	4,441	w.	31	n.	28	1	5	22	9.0	49.3	17.8
Hawaiian Islands																																
Honolulu	38	86	100	[2]29.96	[2]30.00		71.4	+.6	78	16	76	63	6	67	12	66	63	77	5.92	+2.2	19	6,570	e.	30	w.	4	5	9	14	6.8	.0	.0

[1] Observations taken bihourly.

[2] Pressure not reduced to mean of 24 hours.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, February 1933*

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max.+mean min.÷2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*In.*	*In.*	*In.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	*In.*	*In.*	*In.*
Cape Race, N. F	99							24.8		8	4.12		11.5
Sydney, C. B. I	48	29.72	29.77	−0.15	27.4	+8.1	34.7	20.1	49	7	7.45	+3.36	22.9
Halifax, N. S	88	29.69	29.80	−.15	29.7	+7.3	36.8	22.6	51	7	5.32	+.16	6.2
Yarmouth, N. S	65												
Charlottetown, P. E. I	38	29.69	29.73	−.22	25.0	+7.4	31.6	18.4	51	2	2.91	−.15	18.8
Chatham, N. B	28	29.66	29.69	−.27	18.7	+6.2	28.6	8.8	45	−12	2.63	−.53	13.2
Father Point, Que	20	29.78	29.81	−.17	16.8	+5.3	24.2	9.3	38	−8	2.57	−.36	22.1
Quebec, Que	296	29.54	29.87	−.12	18.0	+6.2	24.4	11.7	38	−13	3.82	+.55	37.6
Doucet, Que	1,236				2.9		16.7	−10.8	35	−52	3.94		39.4
Montreal, Que	187	29.68	29.90	−.12	21.6	+7.1	28.8	14.4	40	−12	2.21	−.86	18.9
Ottawa, Ont	236	29.65	29.93	−.09	20.5	+8.8	29.5	11.5	44	−18	1.63	−1.06	14.8
Kingston, Ont	285	29.63	29.96	−.08	25.2	+7.4	32.6	17.7	43	−9	2.28	−.26	13.0
Toronto, Ont	379	20.54	29.97	−.07	26.1	+4.6	32.3	19.9	46	−6	1.62	−.99	6.3
Cochrane, Ont	930				5.7		14.4	−3.0	34	−33	1.26		12.5
White River, Ont	1,244	29.52	29.90	−.12	3.6	+3.4	17.4	−10.3	42	−46	2.69	+1.17	26.9
London, Ont	808				23.7		31.2	16.2	48	−12	2.00		4.8
Southampton, Ont	656	29.20	29.94	−.08	21.9	+2.0	28.5	15.3	48	−6	3.22	+.32	27.9
Parry Sound, Ont	688	29.20	29.93	−.08	17.9	+3.6	25.2	10.6	43	−20	4.74	+1.82	40.0
Port Arthur, Ont	644	29.20	29.94	−.11	9.0	+2.6	17.6	.3	37	−30	.75	−.15	7.5
Winnipeg, Man	760	29.10	29.99	−.11	−1.9	−.3	9.0	−12.8	39	−4.2	.61	−.37	6.1
Minnedosa, Man	1,690	28.05	29.98	−.11	−1.0	+1.7	9.3	−11.4	37	−40	.58	−.03	5.8
Le Pas, Man	860				−6.3		3.9	−16.5	36	−40	.45		4.5
Qu'Appelle, Sask	2,115	27.56	29.94	−.14	2.8	+3.4	13.9	−8.2	40	−41	.74	+.01	7.4
Moose Jaw, Sask	1,759				8.2		20.4	−4.1	47	−38	.25		2.5
Swift Current, Sask	2,392	27.30	29.96	−.11	10.2	+2.2	21.4	−1.0	52	−36	.86	+.12	8.6
Medicine Hat, Alb	2,365	27.37	29.94	−.11	14.3	+3.1	25.0	3.5	53	−28	.38	−.29	3.8
Calgary, Alb	3,540	26.13	29.95	−.04	15.6	+2.1	25.8	5.4	51	−26	.40	−.23	4.0
Banff, Alb	4,521												
Prince Albert, Sask	1,450	28.35	30.02	−.07	−1.7	+1.3	10.1	−13.4	43	−40	.60	−.09	6.0
Battleford, Sask	1,592	28.16	30.01	−.08	.6	+.5	13.2	−12.0	46	−40	.46	+.09	4.6
Edmonton, Alb	2,150												
Kamloops, B.C	1,262												
Victoria, B.C	230	29.89	30.15	+.15	37.2	−2.3	41.6	32.7	48	17	2.84	−1.26	.4
Barkerville, B.C	4,180												
Estevan Point, B.C	20												

LATE REPORTS FOR JANUARY 1933

Prince Rupert, B.C	170												
Hamilton, Ber	151	29.94	30.11	.00	63.1	+1.6	67.9	58.3	73	49	2.88	−1.56	.0
Montreal, Que	187	29.72	29.94	−.10	25.8	+14.1	32.8	18.8	47	−5	2.12	−1.61	11.7
Kamloops, B.C	1,262	28.40	29.71	−.25	29.6	+6.6	34.9	24.3	48	9	.33	−.49	2.7
Estevan Point, B.C	20				39.4		44.2	34.6	49	28	16.27		T
Prince Rupert, B.C	170				34.2		37.7	30.7	46	31	9.81		23.7

SEVERE LOCAL STORMS, FEBRUARY 1933

[Compiled by Mary O. Souder]

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path, (yards)	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Wisconsin, extreme northern counties.	1					Heavy snow	No details	Official, U.S. Weather Bureau.
Marquette, Mich.	4-5					do	do	Do.
Boulder, Mont.	5	P.m.				Blizzard	200 motorists stranded on highway	Do.
Quincy, Mo.	6-7					Rain, sleet, and snow.	Roads impassable	Do.
Wisconsin, southeastern counties.	6-7					Wind and snow	Traffic delayed	Do.
Springfield, Mo., and vicinity.	6-10					Sleet and glaze	Sleet and glaze interfered with traffic; fruit trees damaged.	Do.
Mermenteau, La.	7	8 a.m.	66		$4,500	Probably tornado	Buildings damaged; path 260 yards long	Do.
Jeanerette, La.	7	9:30 a.m.	65		2,000	do	Buildings and timber damaged; path 230 yards long.	Do.
Reserve, La.	7	10:45 a.m.	500-1,600		30,000	do	Property damaged; path 7 miles long	Do.
Houma, La.	7	11:00 a.m.	100		500	Tornado	Damage to buildings; path 800 yards long	Do.
Opelika, Ala.	7					Damaging winds	Transmission lines and trees blown down; property damage not known.	Do.
Chicago, Ill.	7			15		Blizzard	Transportation tie-ups; motorists caught in snow drifts; extensive damage to fruit trees.	Do.
Kansas City, Mo.	7					do	Huge damage to crops and livestock	Do.
Kirksville, Moberly and Jefferson, Mo., and vicinity.	7					Snow	22 telephone circuits were snapped by cold; highways slippery.	Do.
Milwaukee, Wis., and extreme southeastern counties.	7			3		Blizzard	All means of travel stopped; telephone wires snapped.	Do.
Iowa, entire State	7-8					do	All traffic delayed; some lives lost	Do.
Bismarck, N.Dak.	7-8					Wind	Persons and livestock suffered greatly	Do.
Dallas, Tex.	7-9					Ice storm	Several thousand dollars worth of property lost; much damage to fruit trees and early vegetables.	Do.
Indiana, northern and central portions.	8					Snow and wind	Roads in northern section slippery; crews worked all night to keep roads open.	Do.
Michigan, entire State	8					Snow	Snow, from 4 to 20 inches deep, paralyzing traffic and causing death, suffering, and privation; schools closed.	Do.
Binghamton, N.Y.	8-9					Wind, snow, and sleet.	Estimated about 500 men employed to open roadways.	Do.
Knoxville, Tenn.	8-9			2		Ice storm	Several accidents because of slippery pavements.	Do.
Ludington and Mason Counties, Mich.	9					Wind and snow	Traffic paralyzed; roads and schools closed	Do.
Buffalo, N.Y.	9			3		do	Blizzard-like conditions; airplane service at standstill; Grand Island ferry blocked by ice floes.	Do.
Milwaukee, Wis.	9					Damaging winds	Property loss	Do.
Atlanta, Ga.	10	9:50 a.m.				Rain and sleet	Many persons injured by falling on ice; motoring extremely hazardous.	Do.
Raleigh, N.C.	10-11	P.m.				Glaze	Wires were coated with ice; minor breakage in power and other lines.	Do.
Richmond, Va.	10					do	Wires and roads coated with ½ inch of ice; telephone wires broken; street-car traffic interrupted.	Do.
Springfield, Mo.	14	6:40 a.m.				do	Traffic impeded; numerous automobile accidents.	Do.
Milwaukee, Wis.	20	6-12 p.m.			$1,000	Wind	Considerable damage to electric and telephone wires and to windows, signs, and awnings.	Do.
Sault Ste Marie, Mich.	21	A.m.				Gale, electrical, and wind.	No damage reported	Do.
Cheyenne, Wyo.	22					Wind	Small damage to property	Do.

Chart I. Departure (°F.) of the Mean Temperature from the Normal, February, 1933

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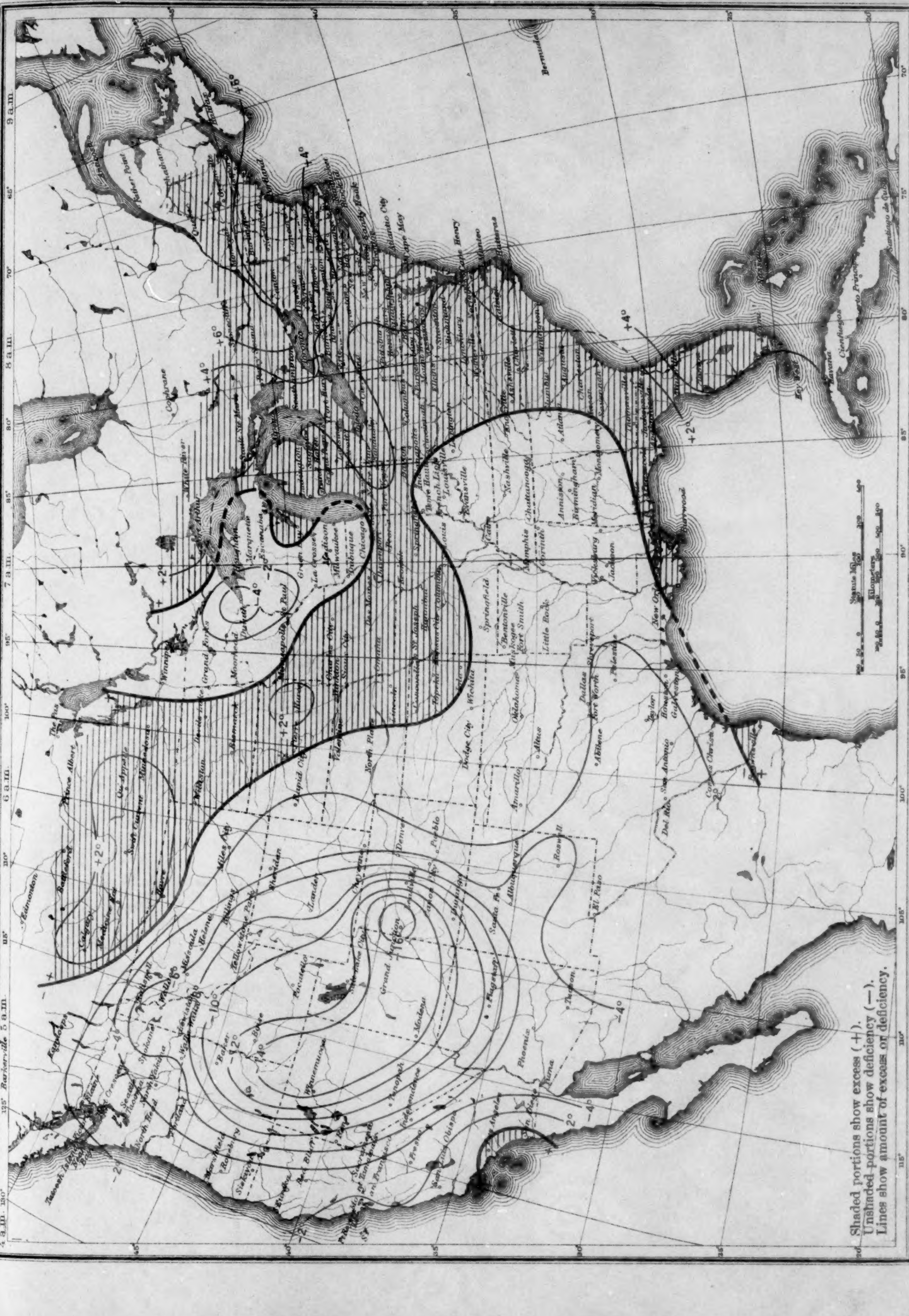
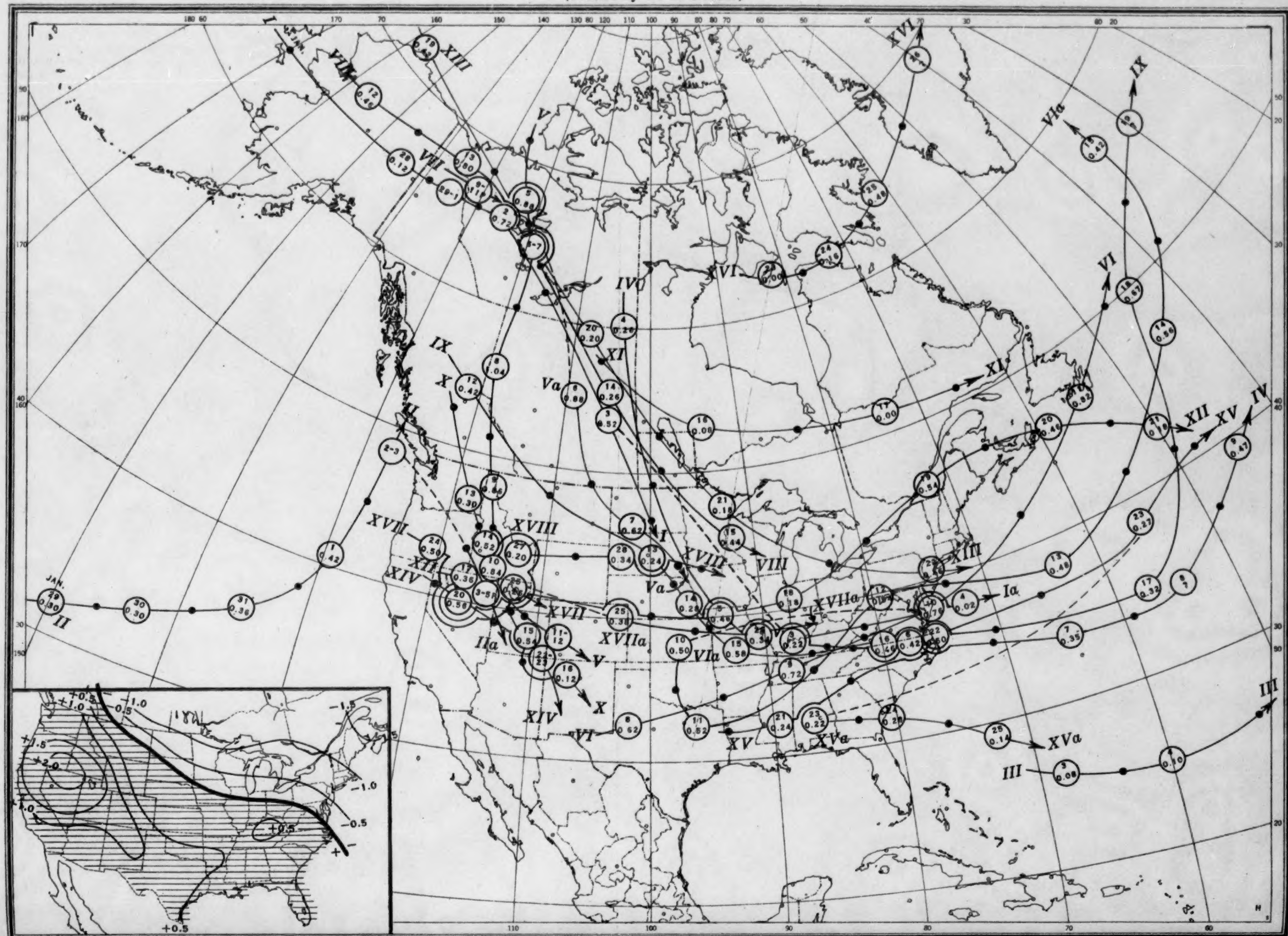


Chart II. Tracks of Centers of Anticyclones, February, 1933. (Inset) Departure of Monthly Mean Pressure from Normal

(Plotted by W. R. Stevens)

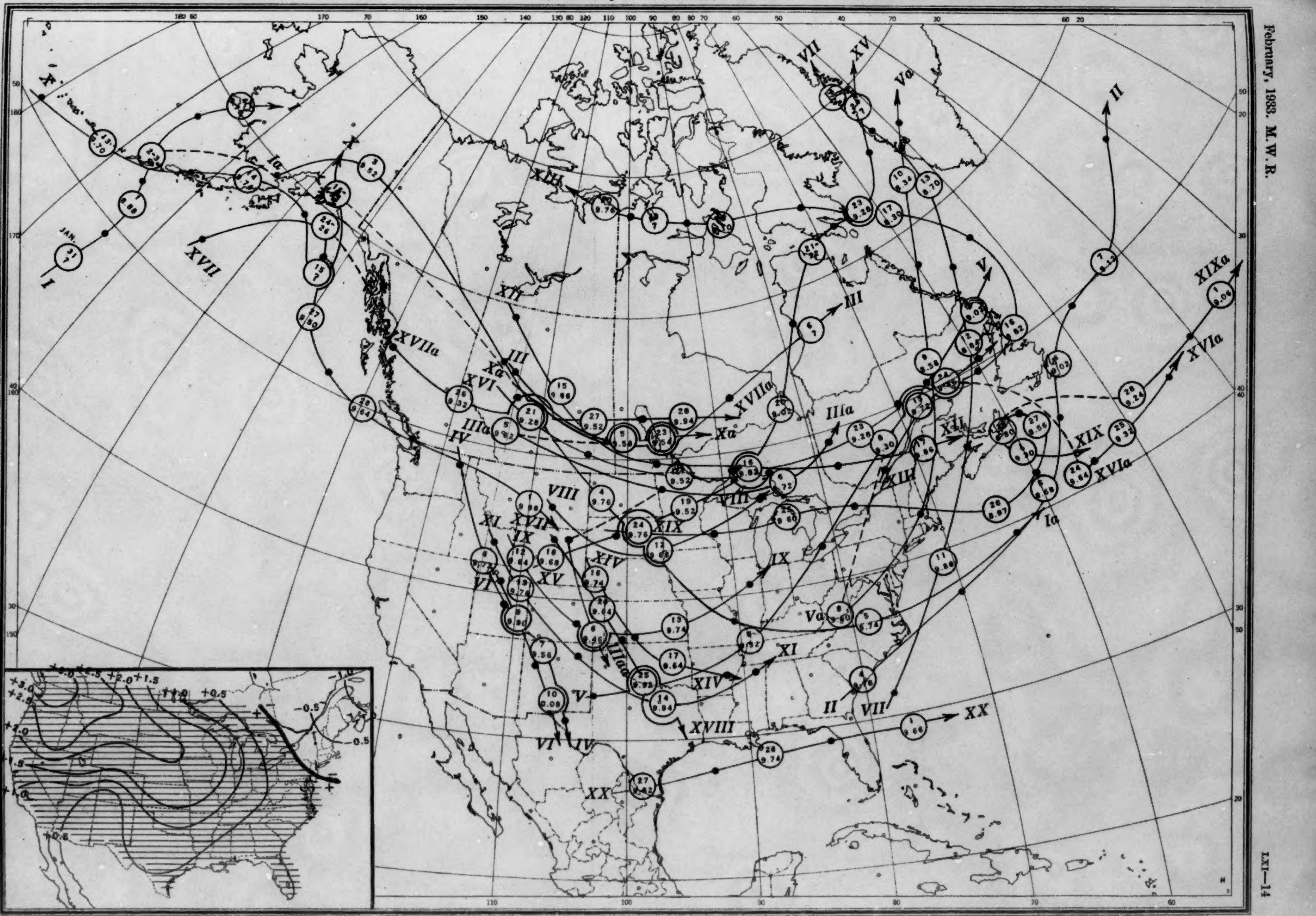


Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, February, 1933. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by W. R. Stevens)

Chart III. Tracks of Centers of Cyclones, February, 1933. (Inset) Change in Mean Pressure from Preceding Month
(Plotted by W. R. Stevens)



Circle indicates position of cyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 8 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky between Sunrise and Sunset, February, 1933

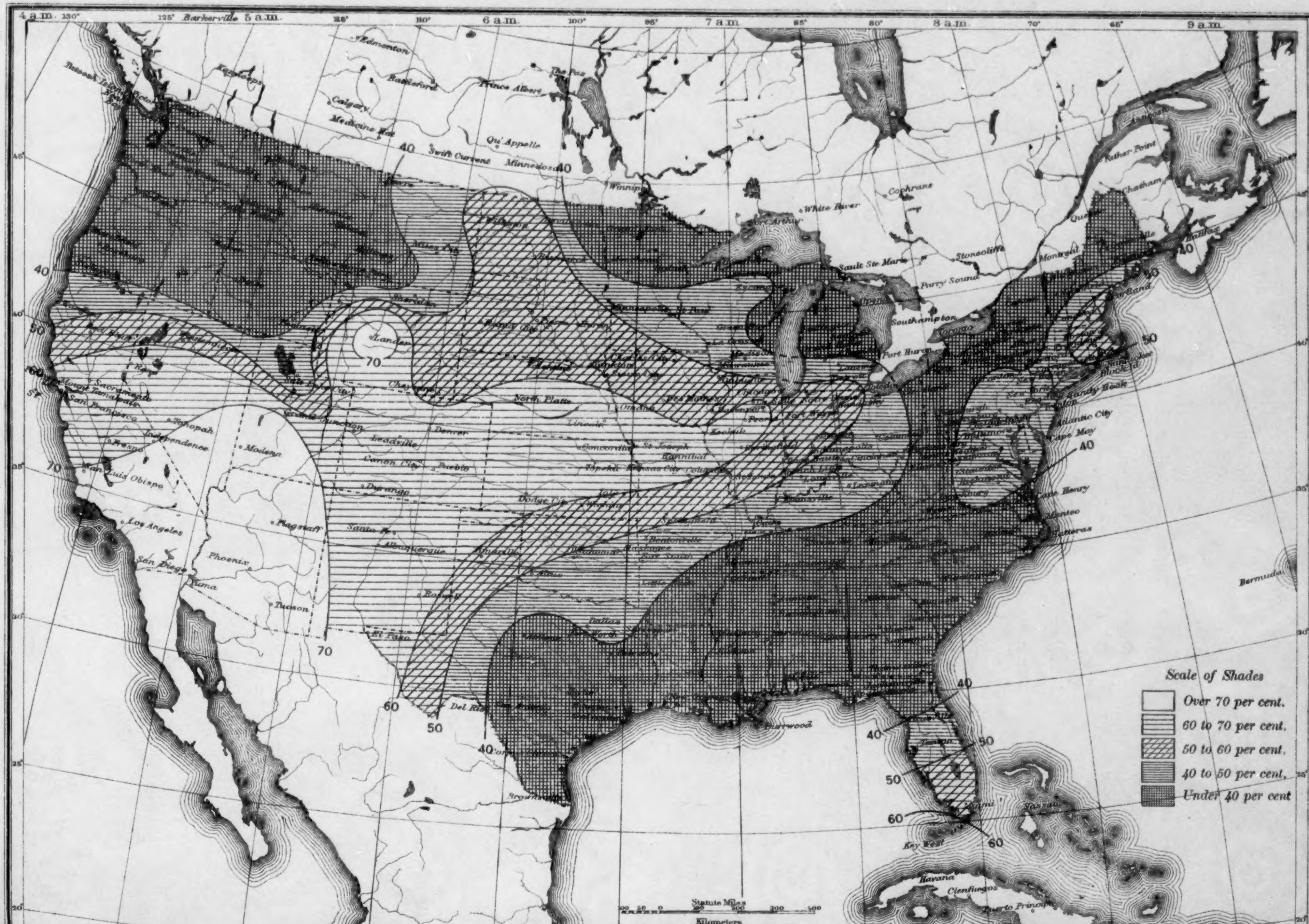


Chart V. Total Precipitation, Inches, February, 1933. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, February, 1933. (Inset) Departure of Precipitation from Normal

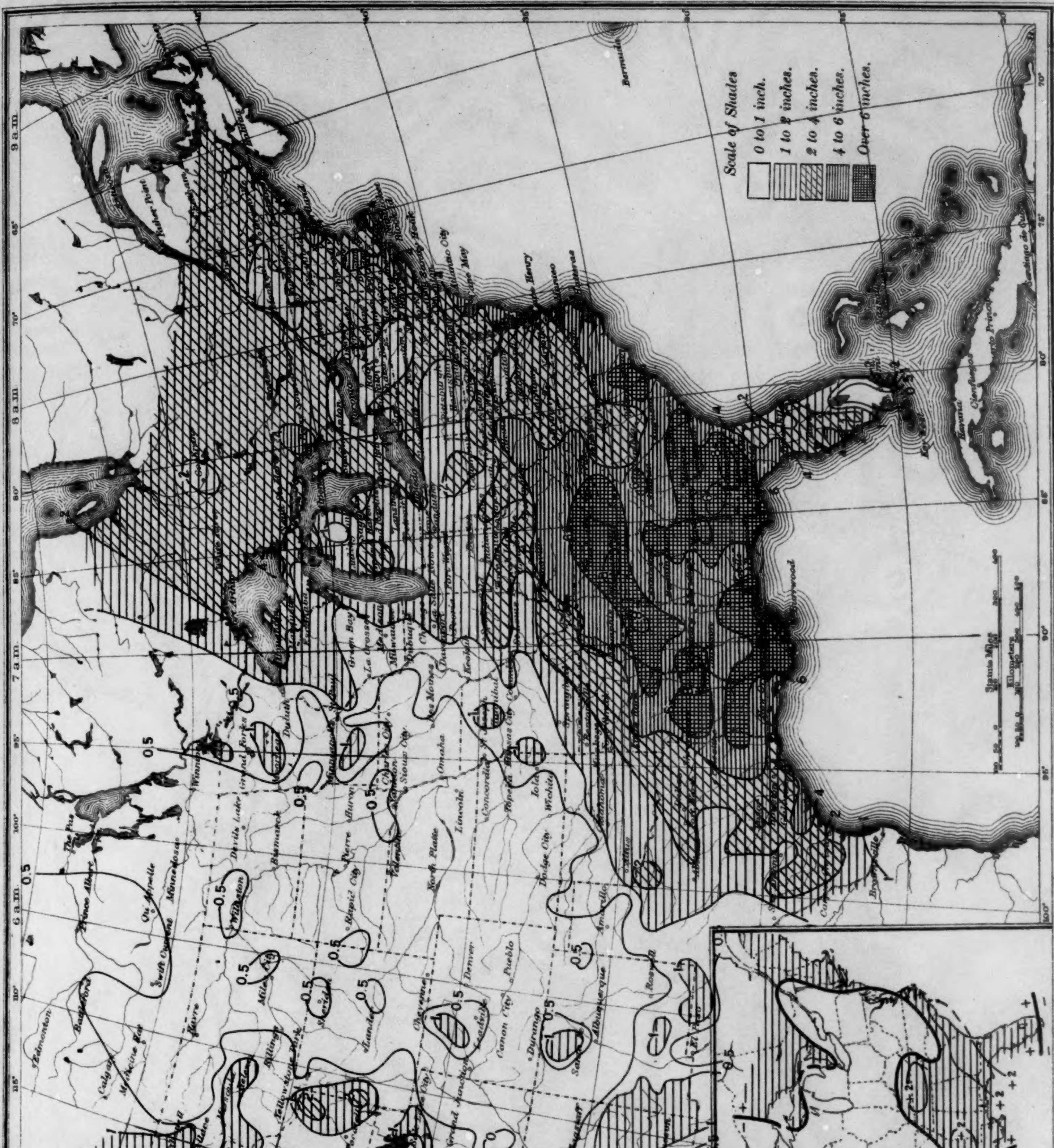


Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, February, 1933

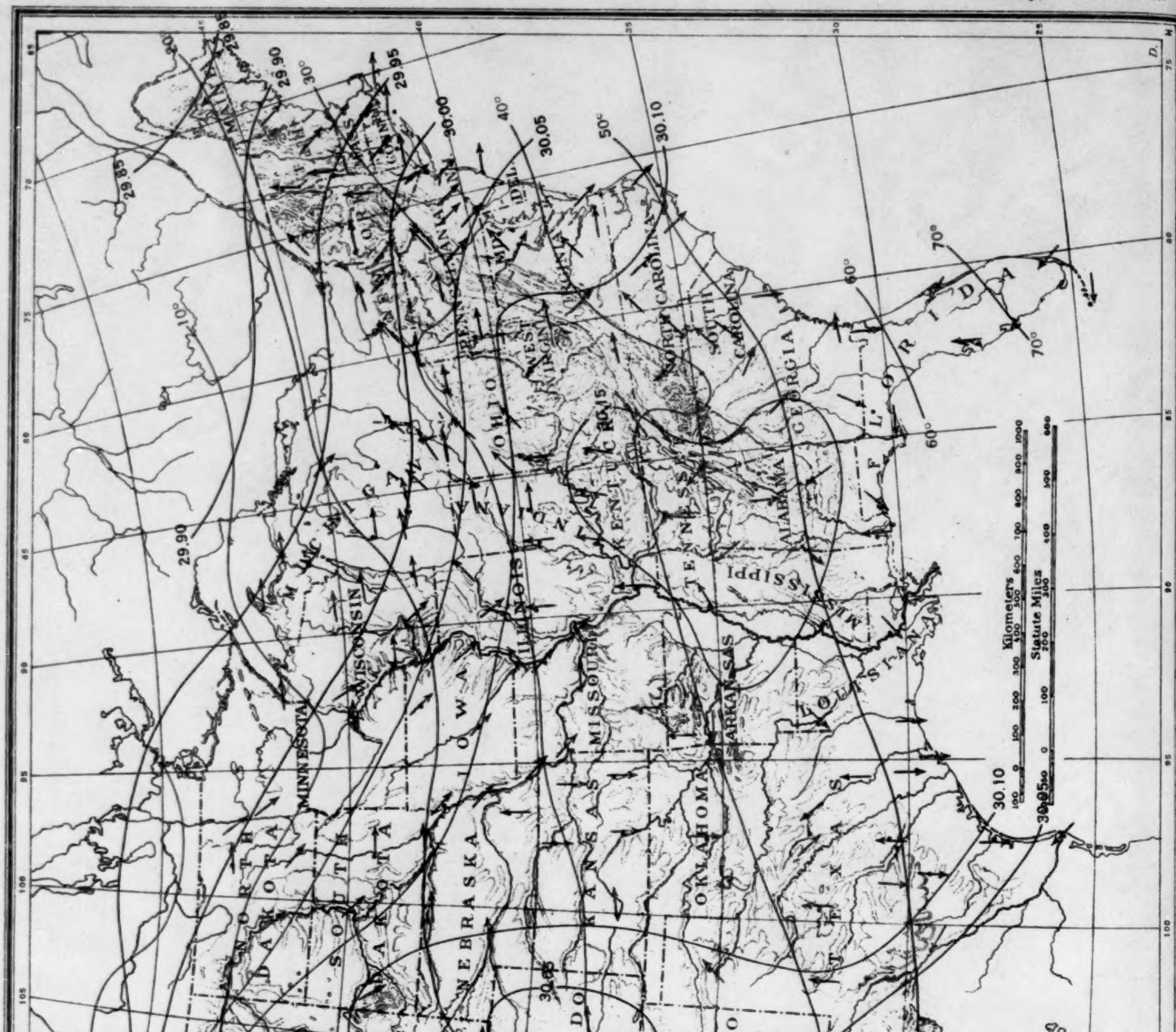


Chart VII. Total Snowfall, Inches, February, 1933. (Inset) Depth of Snow on Ground at 8 p. m., Monday, February 27, 1933

Chart VII. Total Snowfall, Inches, February, 1933. (Inset) Depth of Snow on Ground at 8 p. m., Monday, February 27, 1933

Chart VIII. Weather Map of North Atlantic Ocean, February 7, 1933
(Plotted from the Weather Bureau Northern Hemisphere Chart)

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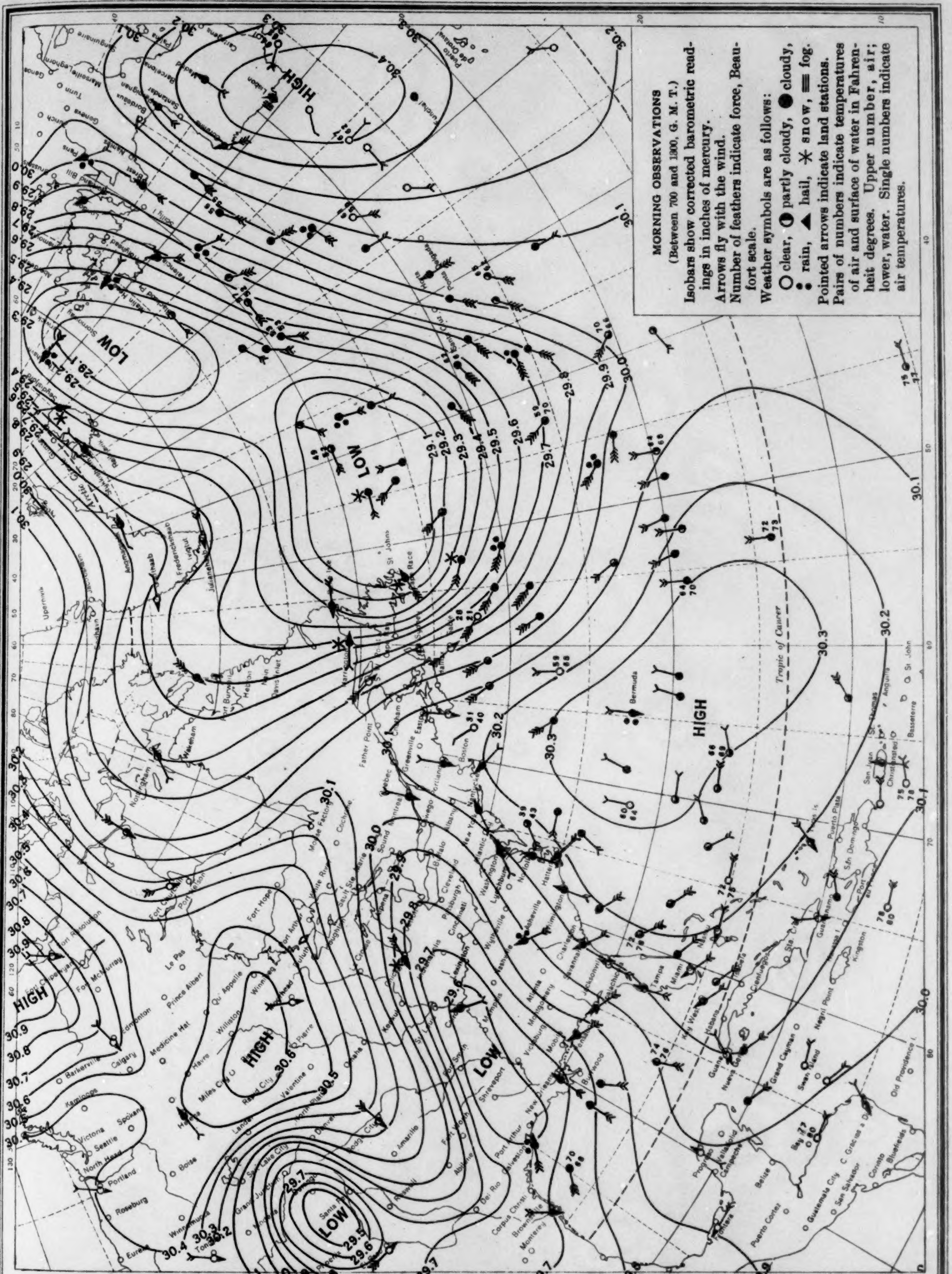
(Plotted from the Weather Bureau Northern Hemisphere Chart)



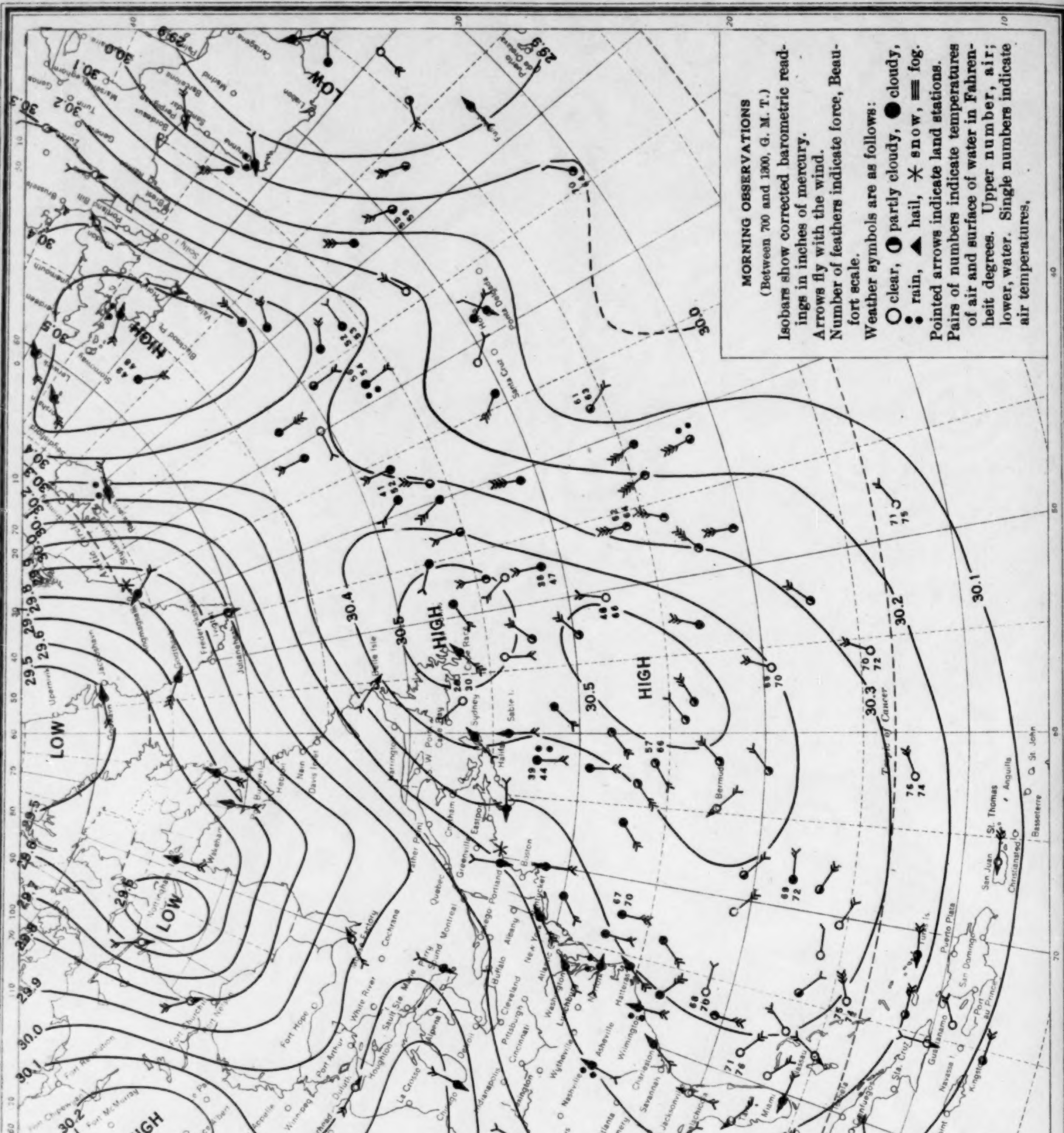


Chart IX. Weather Map of North Atlantic Ocean, February 14, 1933
(Plotted from the Weather Bureau Northern Hemisphere Chart)